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Rustenburg Local Municipality

Electrical Infrastructure Master Plan Update

August 2009 **Final Draft Report Rev.1**

Document History

Revision	Revision Date	Revision Comments	Originator	Reviewed By
1.0	June 2009	First Draft Issue	W J van Zyl	DJ Vrey
6.0	August 2009	Final Draft Issue	W J van Zyl	DJ Vrey
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EXECUTIVE SUMMARY

NETGroup Solution (Pty) Ltd has been appointed by Rustenburg Local Municipality to develop a master plan to facilitate the future growth and upgrading needs of the Municipality's 88/33kV and 33/11kV electricity distribution network in 2006. An upgrade of this plan was requested in 2008.

The main objective of the study was to update the existing electrical network master plan for the distribution networks for the Rustenburg Local Municipality to cater for new developments and to include new growth information..

Study Tasks and Objectives

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

Information Review

During this task as much existing information as possible was obtained. Information included mostly network and load related information. This task further entailed the review of all obtained information.

Refurbishment and Maintenance Planning

A refurbishment and maintenance plan was done in the original study. This plan is still valid.
During this Tasks site specific assessment were conducted to provide a systematic across the board estimate of the life remaining in substation and line facilities, and in conjunction with the life extension methodologies, provide a plan to extend the life to meet future needs. The maintenance planning exercise further identified specific equipment which falls outside the normal refurbishment criteria with the objective of the Maintenance Analysis and Planning to provide a Maintenance Policy with guidelines for the optimisation of maintenance aspects within Rustenburg.

Load Forecast

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

Strengthening Options and Technical Evaluation

The objective of this task was to update and 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:

- Thermal loading,
- Voltage standards, and
- Contingency requirements.

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

The time frames and load representation were for:

- Base year (2008),
- Short-term (2008 - 2012), and
- Longer-term (2012 - 2028).

Cost Estimates and Financial Evaluation

The objective of this task was to estimate the cost of the technically viable expansion and strengthening options. The cost estimates were based on the requirements for:

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

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- and Longer-term. It is recommended that these projects be implemented in the phased manner as indicated.

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.

These scenarios evaluated:

- The Supply Options,
- Distribution network Development, and
- Refurbishment Requirements.

Table of Contents

Figures

Tables

1 Introduction and Background

NETGroup Solutions (Pty) Ltd has been appointed by Rustenburg Local Municipality for the update of the 2006 master plan to facilitate the future expansion needs of the Rustenburg Local Municipality 88/33/11kV electrical distribution networks.

The main objective of the study was to provide the Rustenburg Local Municipality with a clear view and long-term plan for the development of electrical infrastructure required to support the envisaged demand growth in the Rustenburg Town and surrounding areas. The study further evaluated the long-term viability of existing infrastructure and proposed the expansion requirements thereof. The study further clearly identified where new infrastructure should be located and what components, either existing or new, will be required.

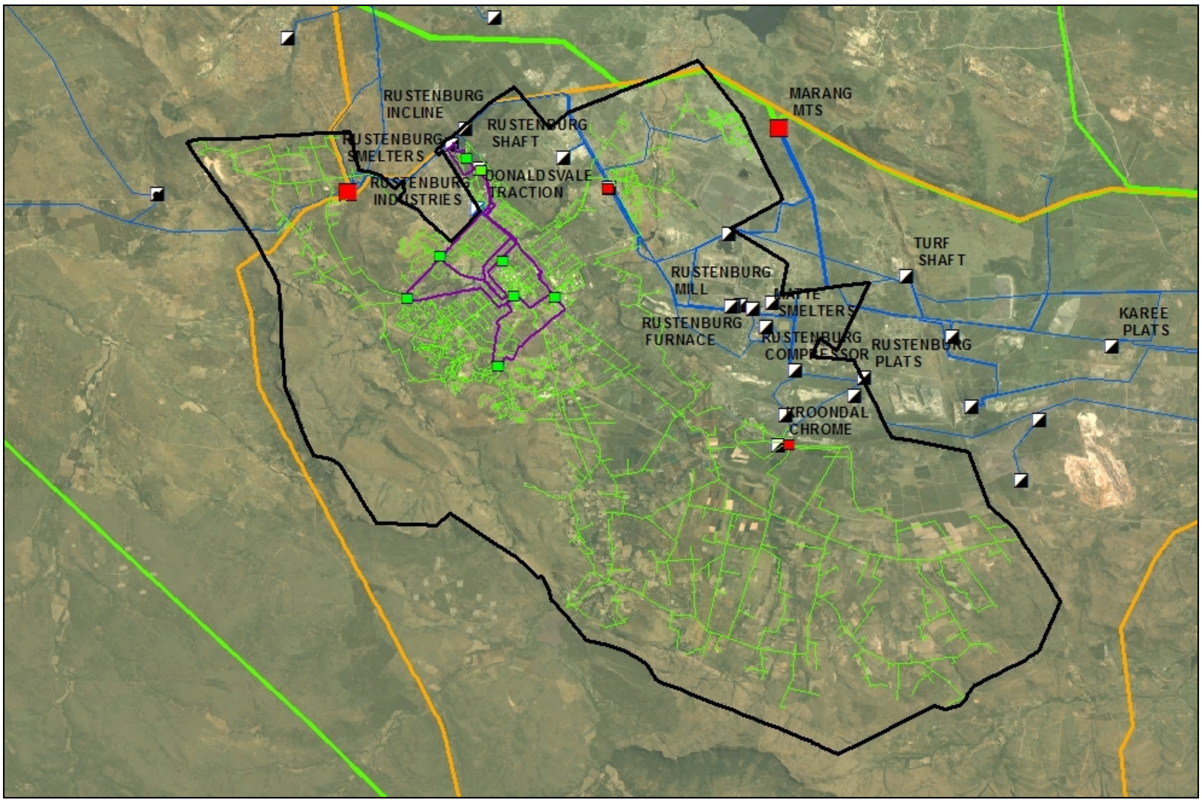

Figure 1-1: Study Area

1.1 Document Structure

This report consists of two Volumes.

Volume A comprises of a technical report providing fundamental methodology, data, analysis aspects, results recommendations.

Volume A of this report consists of the following Sections:

- Section 1 – Introduction and Background
- Section 2 – Provides background with regard to the Methodology and Data that was used during the study,
- Section 3 – Discusses the approach that was followed to develop the Distribution Network Model,
- Section 4 – Provides the Load Forecast, Methodology and Results,
- 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 of the proposed network development.

The Network Assessment supporting information is provided in Addendum A.

Volume B provides a set of geographical diagrams that systematically show the network development plan for the Rusterburg Sub – Transmission and Distribution network.

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. The Strategic and Environmental assessment is not included in this study, and will form part of the project implementation.

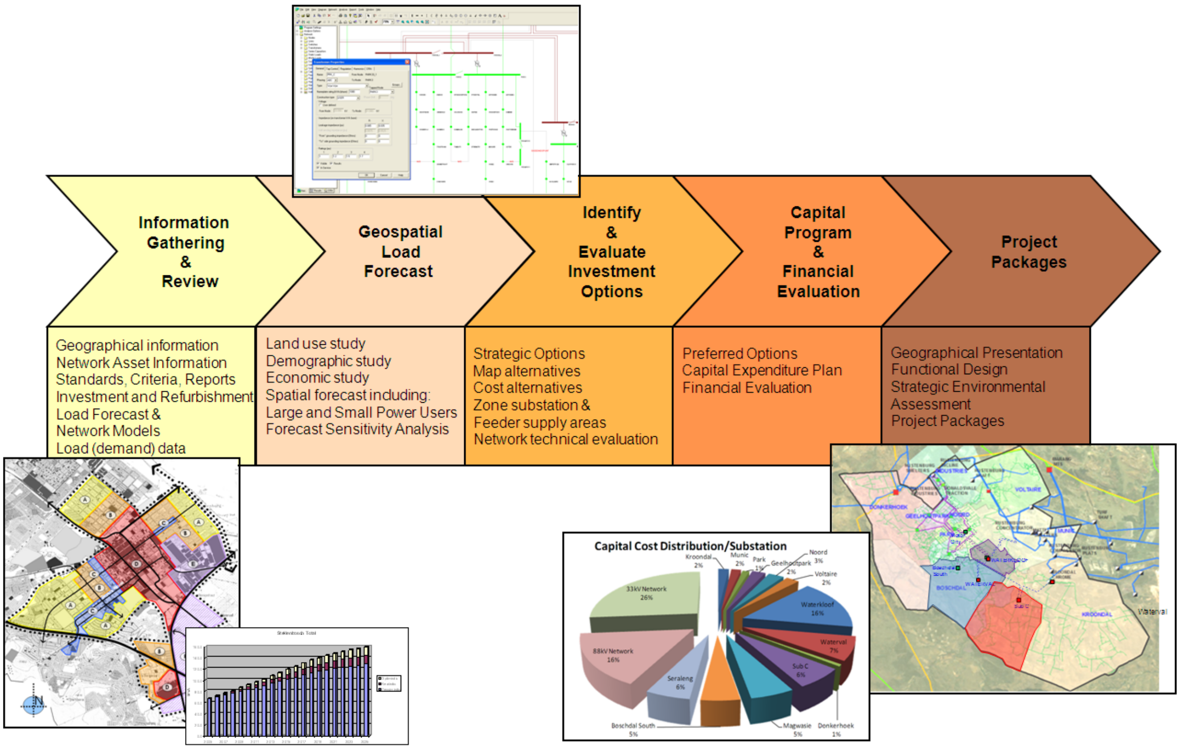

Figure 2-1: Network Expansion and Strengthening Planning Process

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 Geographical 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.

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2.1.3 Distribution Model

The objective of this Task was to develop an adequate network model representing the entire Rustenburg Distribution network up-to 11kV main feeder level. Various load points, representing the feeder load will be modelled at sufficient intervals along the feeder to assess adequacy in terms of thermal and voltage criteria.

2.1.4 Strengthening Options and Technical Evaluation

This task clearly defined the network problems by assessing the existing network capability and analysing the shortcomings in a coordinated manner. In this way all the existing network problems were identified, along with any potential future problems, within the study area. Different networks to supply the expected load were identified within a workshop environment and analysed and evaluated properly to ensure that each alternative network complies with required standards. Once this was achieved the alternatives were cost and compared technically.

The objective of this task was to review the adequacy of the electrical distribution network through load flow and contingency analysis. The need for possible new supply stations was also evaluated. This task was conducted through an iterative process of problem identification, modelling and analysis, discussion of result in a workshop environment and the rework and evaluation of possible solutions as identified through interaction of the planning team.

Network analysis will aim to test compliance with the following minimum requirements:

- Thermal loading,
- Voltage standards, and
- Contingency requirements.

2.1.5 Cost Estimates

The objective of this task was to estimate the cost 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:

- Historical billing information for key customers,
- Historical Eskom supply information (three years),
- Land-use information for Rustenburg,
- Rustenburg Local Spatial Development Framework 2015,
- Development initiatives as discussed with Town Planners,

- Rustenburg supply load profiles, and
- Existing network single line diagrams for Rustenburg HV / MV networks.

2.2.2 Other Information

The following is a list of information that was sourced by NETGroup 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 using ESRI ArcMap 9

2.3.2 Network Analysis

The PTI power flow analysis program, PSS/Adept Rev 5.0 was used throughout the analysis.

3 Distribution Network Model

3.1 Distribution Model

The objective of this task was to develop an adequate network model representing the entire Rustenburg Distribution network up-to 11kV main feeder level. A main feeder was defined as the main feeder being supplied from a distribution substation protected through a feeder circuit breaker. The main feeder model did not include spur networks or transformers supplied from this feeder. Various load points, representing the feeder load were modelled at sufficient intervals along the feeder to assess adequacy in terms of thermal and voltage criteria. The 88kV, 33kV and 11kV networks for the entire supply area will be modelled as stipulated above.

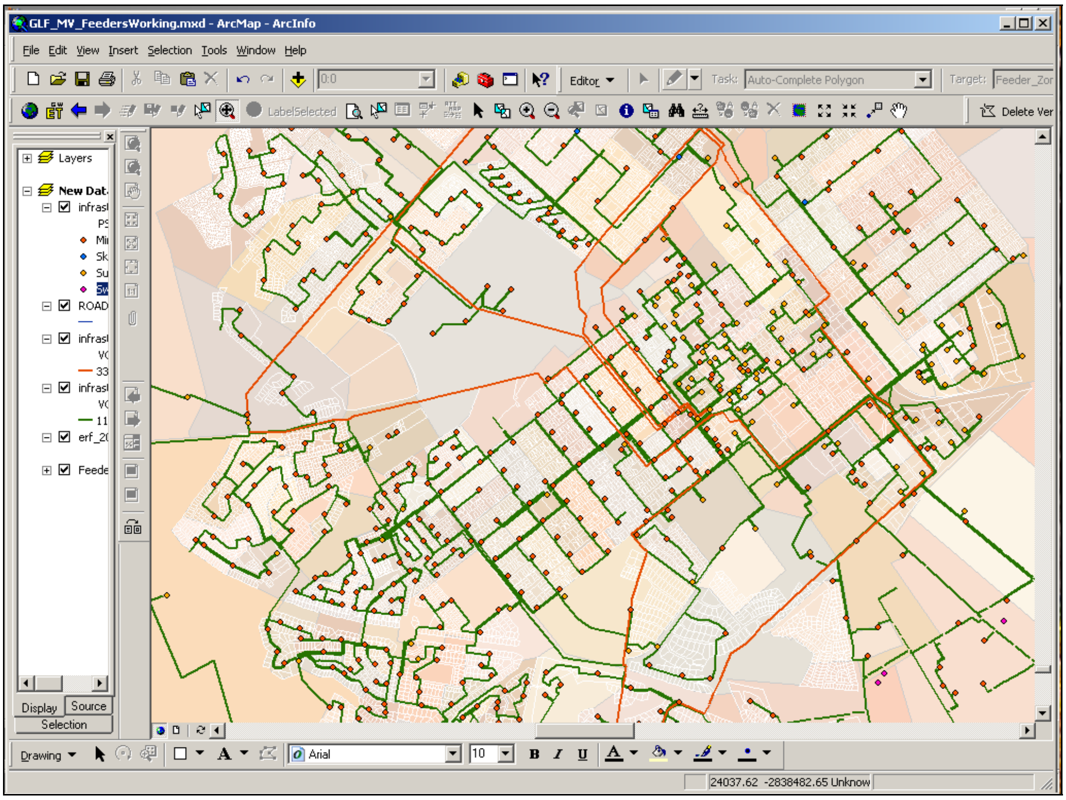


Figure 3-1: Overview of the Rustenburg Geographical Distribution Model

Figure 4-1 provides an overview of the Distribution model within ArcMap.

Figure 4-2 shows the Rustenburg network in PTI's PSS/Adept that was used for load flow and contingency analysis.

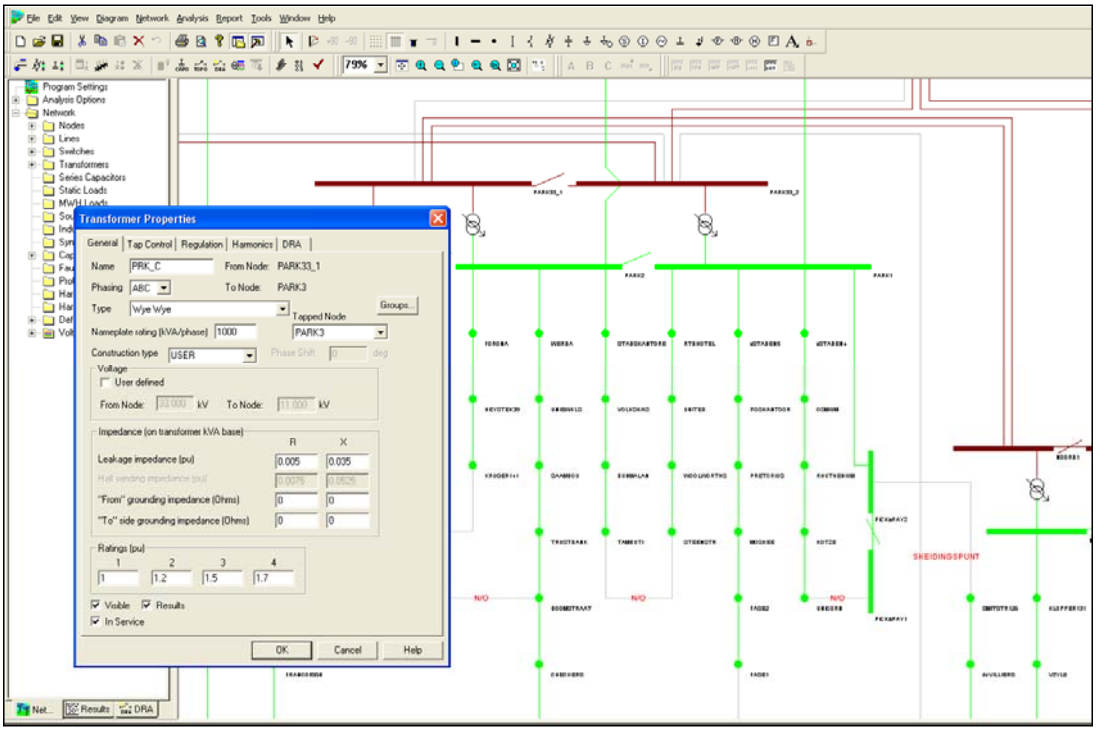


Figure 3-2: Distribution Network in PSS/Adept

4 Load Forecast

4.1 Demand Forecast

4.1.1 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 per customer category.

A 20 year Demand and Energy forecast was developed based on international best practice techniques. The load forecasting technique was based on the research done by H. Lee Willis from North Carolina, USA and as documented in his reputable text book "Spatial Electric Load Forecasting" dated 1996.

4.1.2 Methodology

The load forecast is deterministic in nature and was performed in NETGroup's PowerGLF application where the loads were summated, taking load diversity into account, for each transformer zone.

The load forecast used as basis:

- Futuristic economic information,
- Demographic trends,
- Available land use data, and
- Future development initiatives.

4.1.3 Base Load Set-up

The base load development consisted of creating a data set and associated geographical presentation of the existing network topology and associated loads.

Historical load data, Large Power User (LPU) information and transformer loading information were assigned to feeder zones to represent the base load.

4.1.4 Base Information

The following sections provide background and supporting information to the data and methods that was used to develop the base load.

4.1.5 Set-up Load Forecast Database

All load zones were entered into PowerGLF and linked to ArcGIS. This enabled reporting on maps, providing a visual perception of growth areas. The measured load profiles per load classification were further linked and calibrated to load zones.

The summation hierarchy used to complete the Geographical Load Forecast is shown below:

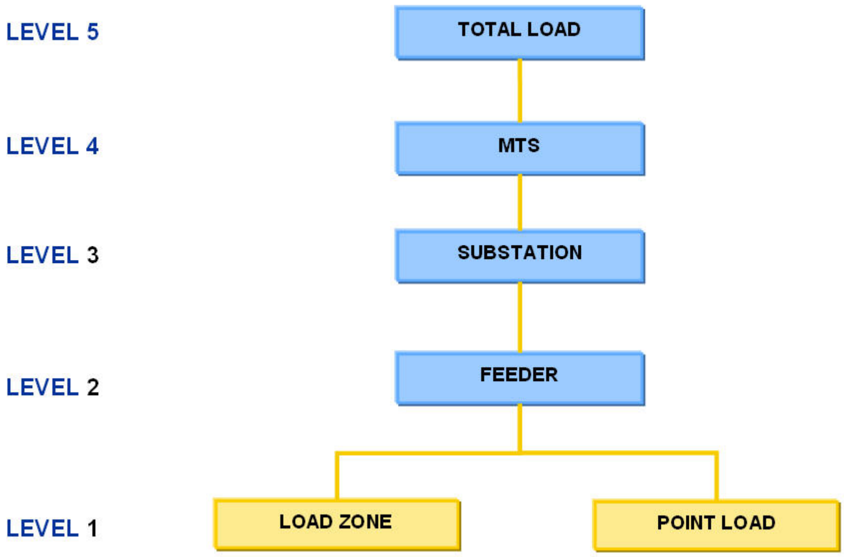


Figure 4-1: Summation Hierarchy

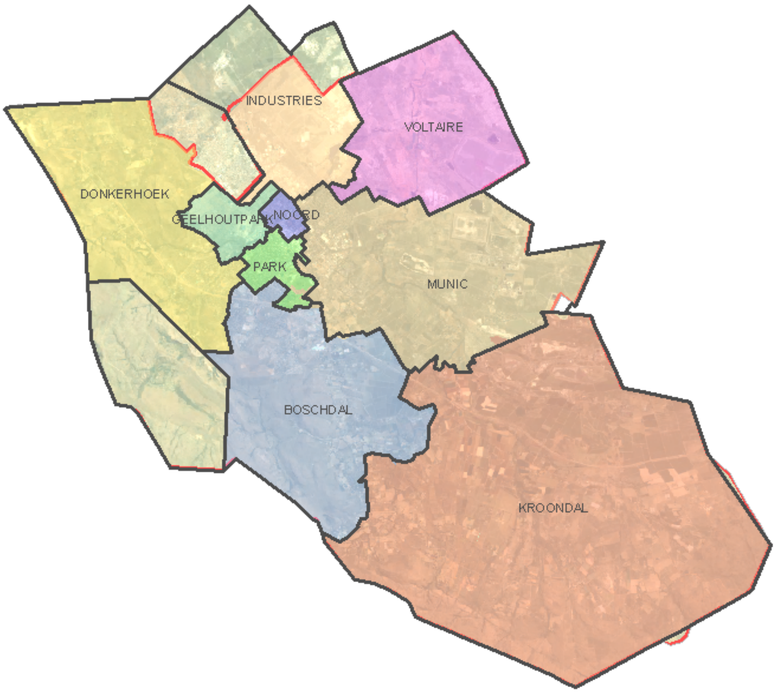


Figure 4-2: Load Zones According to Existing Substation Supply Areas

4.1.6 Strategic Inputs

A development perspective was obtained from the Spatial Development framework that was developed by Urban Dynamics.

The vision for the spatial development of the Rustenburg Municipal Area is to:

- Integrate the existing urban structure,
- Provide a greater housing typology mix,
- Provide social amenities in an equitable manner,
- Protect commercial agriculture and natural open spaces,
- Enable the cost-effective provision of bulk municipal services,
- Rationalise transportation infrastructure and services provision, specifically public transportation,
- Capitalise on the economic competitive advantages in the region, such as mining and the Platinum SDI.

The objectives with regard to the spatial development of the Rustenburg Municipal Area were based on the vision set out above and include the following:

- Promote a compact urban structure through urban infill and densification, specifically within the settlement clusters,
- Create a logical hierarchy of settlements to support effective service delivery,
- Create an urban edge to contain urban sprawl,

- Focus rural development around key rural settlements,
- Redirect the focus of rural settlements located close to water sources on intensive agriculture to lessen their dependence on the Rustenburg core area,
- Strengthen rural centers as centers of service delivery,
- Identify and strengthen gateways to Rustenburg through appropriate urban design, landscaping and development control,

4.1.7 Local Spatial Development Framework

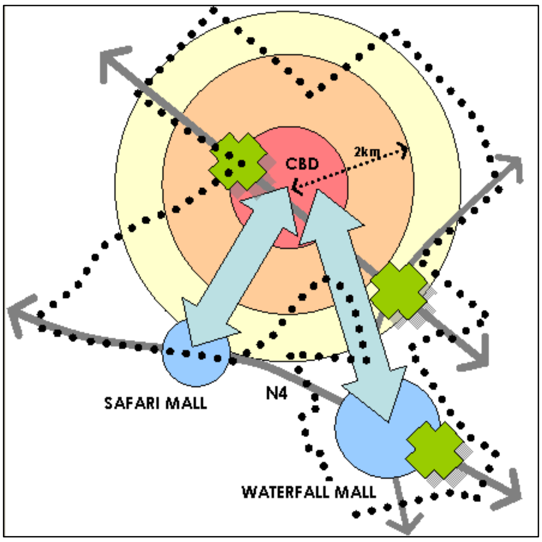
Economic activity within Rustenburg town revolves around 2 primary geographical areas. The first is the CBD and the fringes of the CBD that will absorb its development pressures. The second is the mixed-use precinct along the N4 freeway.

4.1.7.1 Expansion and Protection of CBD

The Rustenburg CBD, and specifically the fringes of the CBD, will need to be subjected to appropriate land use control to ensure that the future development of the CBD results in a viable and functional urban environment that serves as the economic and social heart of the Rustenburg Municipality.

Primarily, the Rustenburg CBD comprises a core area, an inner fringe area and outer fringe area. Because the inner fringe is located adjacent to the core area, it functions as a transition area between the core area and the predominantly low-density residential areas of the outer fringe. The inner fringe typically comprises a mix of low-density residential, higher-density residential, office uses and business uses. This development trend should be managed in a manner that would ensure the orderly and integrated development there of. The haphazard and disjointed development of these areas, specifically the inner fringe, should be avoided through the strict management of these precincts.

Apart from the natural, concentric expansion of the CBD, the N4 freeway has a significant influence on the future development of the CBD. On the one hand, the N4 will stimulate the development of the CBD along the Johannesburg Road towards the Waterfall Mall intersection and, on the other hand, it will facilitate the growth of the CBD along Beyers Naude Drive towards the Safari intersection. Strong nodal development will and is already taking place at the abovementioned intersections.

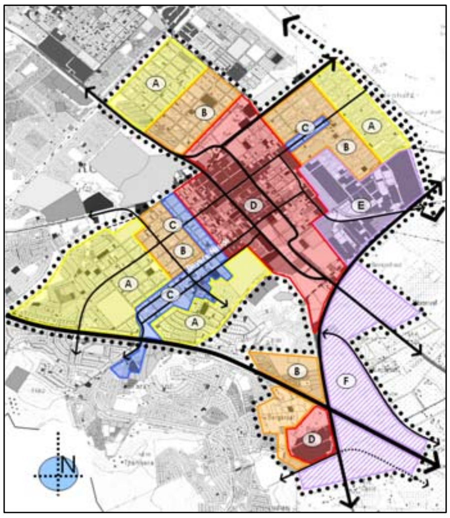


The development opportunities created at these nodes by a strong natural growth momentum should be optimally utilized and harnessed through appropriate planning of these areas.

Not only will the abovementioned intersections become major activity nodes within the Municipal Area, but they will also shift the entrance and focus of Rustenburg. The Waterfall Mall intersection will become the primary gateway to Rustenburg and should be appropriately planned on a spatial, aesthetic and city-image level. In addition, the northern and southern entrances of the CBD should remain gateways as proposed in the CBD Regeneration Study, and should be treated as such.

4.1.8 Development of Mixed-used Precinct

Beyers Naude is linked to the N4 freeway and will therefore become a major access route to the CBD, which in turn will stimulate land use change in this area. Delineating this area for office uses will ensure that land use change is restricted to a specific geographical area and that change takes place in an orderly manner. An office corridor area is thus proposed between the boundaries of the CBD area along Beyers Naude Drive up to the Safari Retail Complex. This area will be specifically earmarked for offices and medical consulting rooms.



The developments identified in the area which is already in the planning or approval phase are shown in figure 4.3 below. Other potential developments are included in the land use calculation for specific areas.

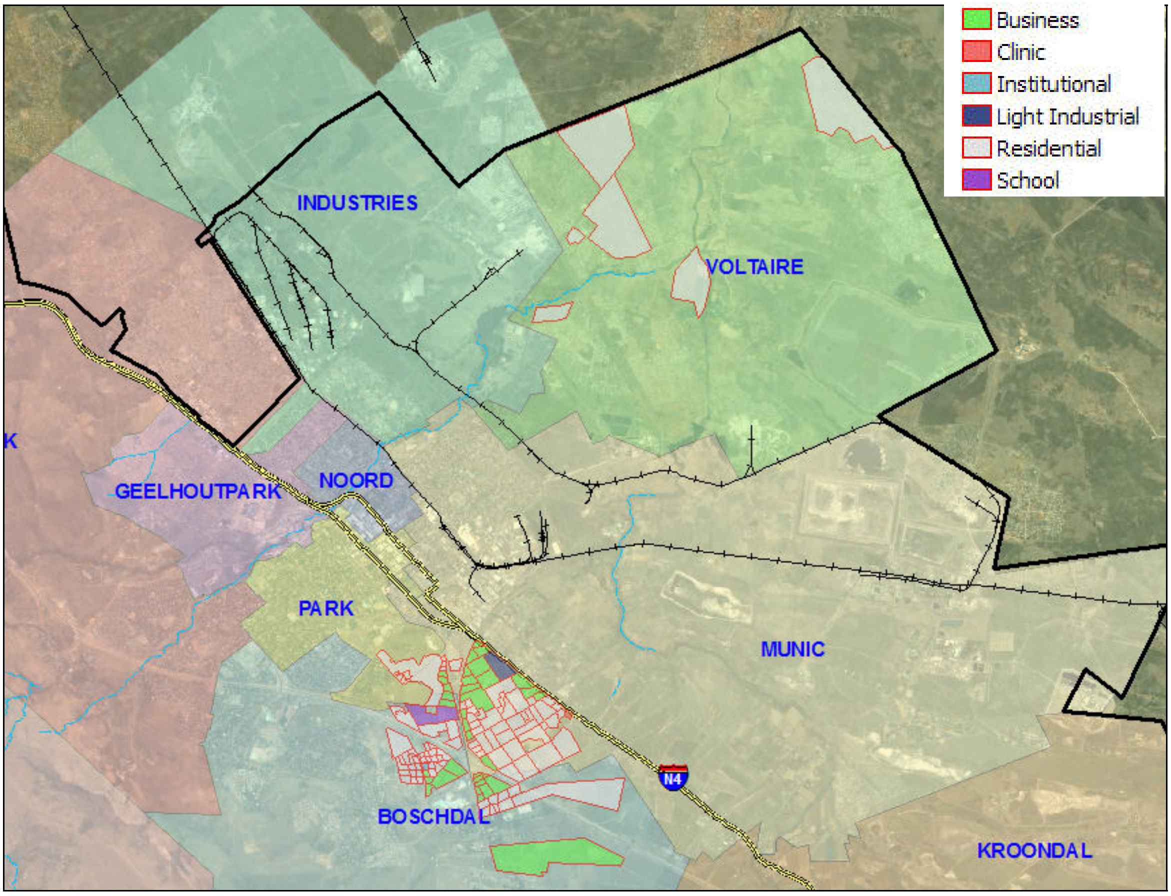


Figure 4-3: Load Zones According to Land-use

4.1.9 Geographical Load Zoning

The complete study area was zoned in order to obtain a geographical base for the load forecast. The load zones varied in size depending on the activity and density of a specific area. The load zone boundaries follow existing transformer supply areas – this is important to be able to derive the current load per load zone. Arial photography, as illustrated, as well as cadastral information was used to further guide this zoning. All load zones were captured in a GIS as database, which enabled proper reporting.

A typical portion of the load zones as captured in ArcMap is shown below:

Figure 4-4: Load Zones According to Land-use

4.1.10 Land-use Characteristics

The number of load classifications that was used in the load forecast was determined in consultation with Rustenburg Local Municipality. Weekly load profiles for a number of these classifications were further measured. The table below shows the definitions for the various classifications that were used.

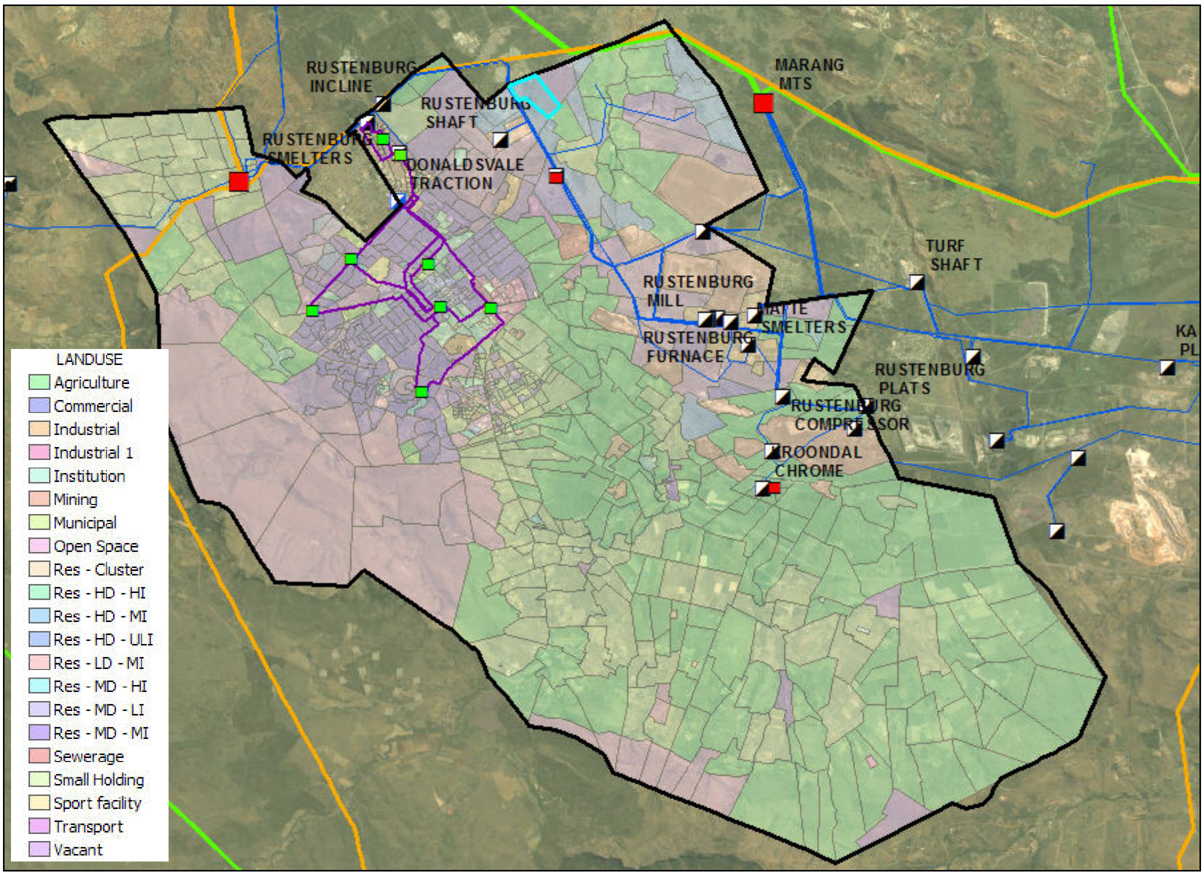


Figure 4-5: Land Use within GIS

Land Use Data		
Land Use ID	**Land Use Description**	**Profile ID**
Agriculture High	Agriculture High	AH
Agriculture	Agriculture	AH
Commercial	CBD	Comm3
Industrial	Industrial	Ind3
Industrial1	Industrial High	Industrial High
Institution	Commercial	Comm3
Mining	Mining	Mining& Quarrying
Municipal	Commercial	Government Admin
Open Space	Open Space	Open Space
Res - Cluster	Residential Cluster	Residential High
Res – HD – HI	Residential – High Density – High Income	Residential – High Density – High Income
Res – HD – LI	Residential – High Density – Low Income	Residential – High Density – Low Income

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Res – HD – MI	Residential – High Density – Medium Income	Residential – High Density – Medium Income
Res – HD – ULI	Residential – High Density – Ultra Low Income	Residential – High Density – Ultra Low Income
Res – LD – HI	Residential – Low Density – High Income	Residential – Low Density – High Income
Res – LD – LI	Residential – Low Density – Low Income	Residential – Low Density – Low Income
Res – LD – MI	Residential – Low Density – Medium Income	Residential – Low Density – Medium Income
Res – LD – ULI	Residential – Low Density – Ultra Low Income	Residential – Low Density – Ultra Low Income
Res – MD – HI	Residential – Medium Density – High Income	Residential – Medium Density – High Income
Res – MD – LI	Residential – Medium Density – Low Income	Residential – Medium Density – Low Income
Res – MD – MI	Residential – Medium Density – Medium Income	Residential – Medium Density – Medium Income
Res – MD – ULI	Residential – Medium Density – Ultra Low Income	Residential – Medium Density – Ultra Low Income
Sewerage	Commercial	Wastewater
Small Holding	Small Holding	Residential Medium
Sport Facility	Commercial	Sport & Recreation
Transport	Commercial	Commercial
Vacant	Vacant	Vacant

Table 4-1: Land Use Type Matrix

4.1.11 Large Customers

A total number of 106 key customers were identified from the available billing data and were geographically positioned on the GIS. Modelling the large customers as point loads substantially increased the overall accuracy of the forecast.

4.2 Geographical Load Forecasting

4.2.1 Set-up Load Forecast Database

All load zones were entered into PowerGLF and linked to the GIS. This enabled reporting on maps, providing a visual perception of growth areas. The measured load profiles per load classification were further linked and calibrated to load zones.

4.2.2 Short- and Long-term Forecasting

For the Long-term forecast, the inputs from the development perspective were used to determine saturation loads. An S-curve was fitted between the Short-term forecast and the saturation load. The PowerGLF package automates a substantial portion of the above-mentioned process.

Special attention was given to the previously mentioned, envisaged development initiatives.

4.3 Base Load Verification

4.3.1 Check Load Densities

The calculation of existing land use load must be equal to the existing load measured. It must be ensured that when the load density is multiplied by the area of the load zone and then multiplied by the coincidence factor, with regard to the maximum time value for that supply zone, the different summated load should be equal to the measured value for that supply zone.

This calculation is done by using the load densities and load portion area and then multiplying that with the specific day profile for the maximum of the supply area. The different load zones are then summated to find a new daily profile, which is then normalized back to the measured theoretical profile. This determines the initial load zones load and also the initial density of each load zone.

4.3.2 Allocate Correct S-Curves

The S-Curves were chosen to simulate a specific land use “road” to saturation. The S-curve’s are mathematically defined as follow:

$$f(n) = A + \frac{D}{(1 + C \cdot e^{-B \cdot n})} \qquad (5.1)$$

Where:

- A defines the initial departure point in per unit,
- B defines the time till saturation,
- C defines the initial slope of the S-Curve, and
- D is always one.

The S-Curves that were used are shown in the following Figure 5-4:

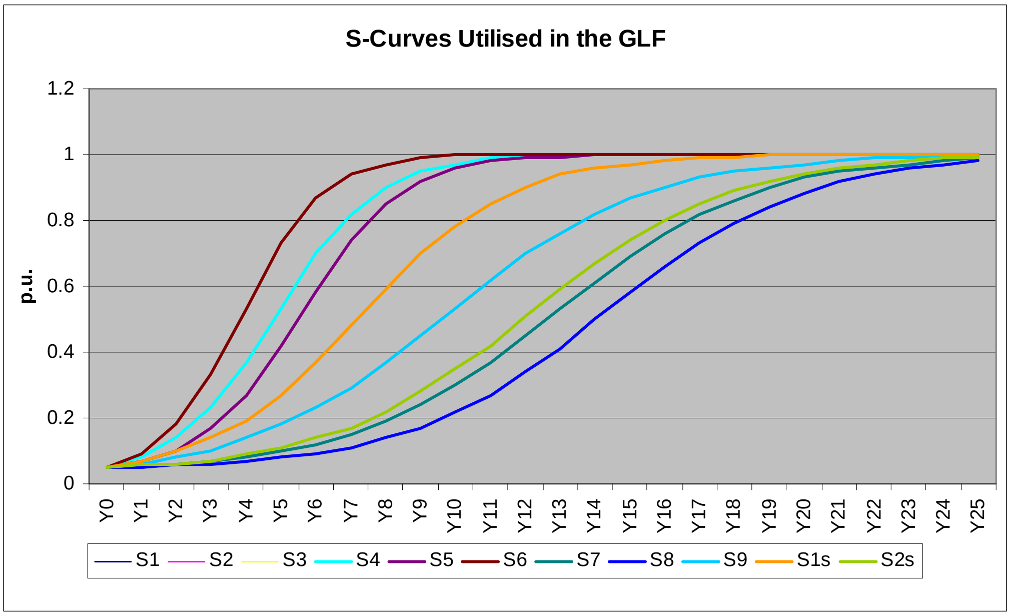


Figure 4-6: Load Category S-Curves

The different types of land uses were appointed different S-curves as follows:

Land Use ID	Land Use Data Profile ID	S Curve ID
Agriculture High	AH	S2
Agriculture	AH	S2
Commercial	Comm3	S1
Industrial	Ind3	S5
Industrial1	Industrial High	S4
Institution	Comm3	S6
Mining	Mining& Quarrying	S1
Municipal	Government Admin	S6
Open Space	Open Space	S
Res - Cluster	Residential High	S8
Res – HD – HI	Residential – High Density – High Income	S8
Res – HD – LI	Residential – High Density – Low Income	S8
Res – HD – MI	Residential – High Density – Medium Income	S8
Res – HD – ULI	Residential – High Density – Ultra Low Income	S8
Res – LD – HI	Residential – Low Density – High Income	S8
Res – LD – LI	Residential – Low Density – Low Income	S8
Res – LD – MI	Residential – Low Density – Medium Income	S8
Res – LD – ULI	Residential – Low Density – Ultra Low Income	S8
Res – MD – HI	Residential – Medium Density – High Income	S8

Res – MD – LI	Residential – Medium Density – Low Income	S8
Res – MD – MI	Residential – Medium Density – Medium Income	S8
Res – MD – ULI	Residential – Medium Density – Ultra Low Income	S8
Sewerage	Wastewater	S1
Small Holding	Residential Medium	S2
Sport Facility	Sport & Recreation	S1
Transport	Commercial	S1
Vacant	Vacant	S

Table 4-2: Load Category S – Curves

The allocation of S-Curves was based on experience in other utilities and should be sufficient to describe the growth pattern.

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 3%.

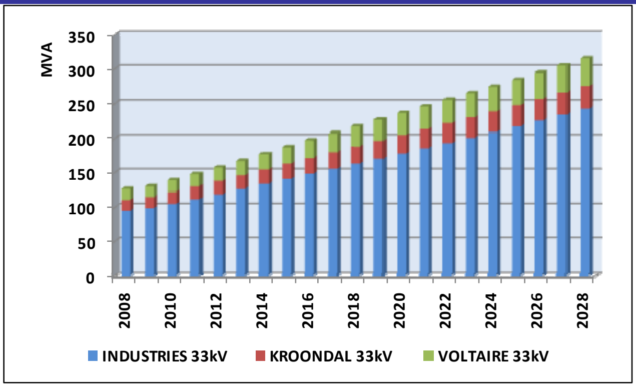
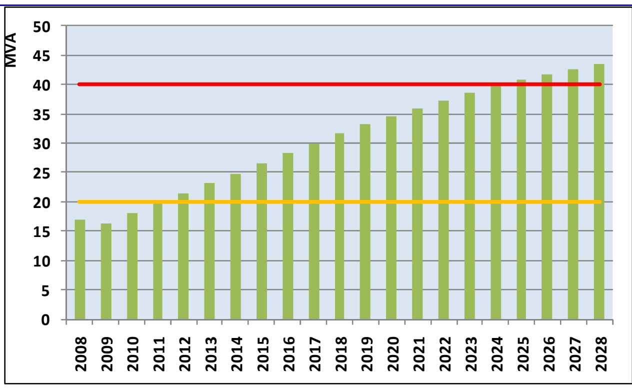
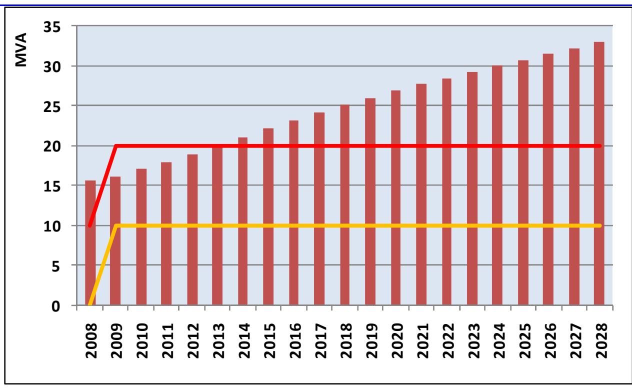
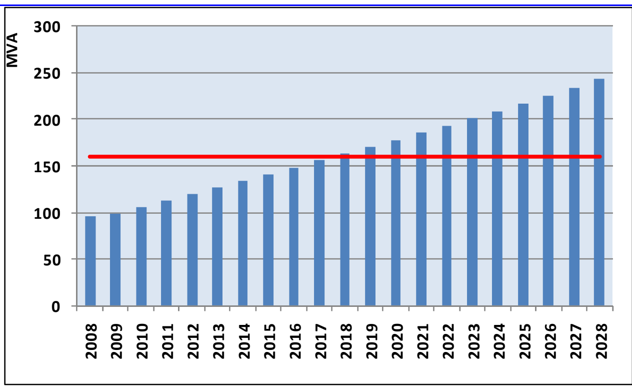
Land use changes that do occur will also be limited to similar land use density in that same supply area (although some exceptions can occur). These are all checked and densities modified until all growth rates are within expectations.

4.3.3 Verify Total Load

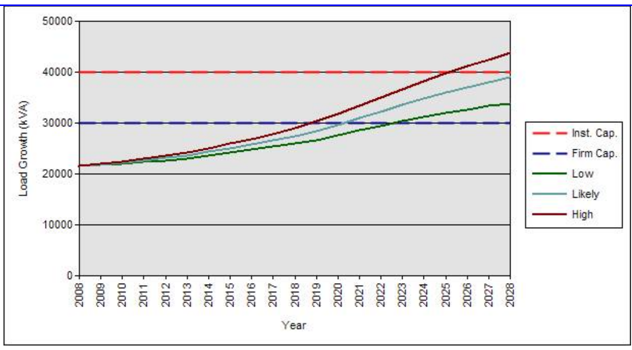
The diversified summated forecast to the top level, namely infeed supply areas must also be acceptable. Historically measured loads are always a good reference to determine whether the forecast is valid.

4.4 Results

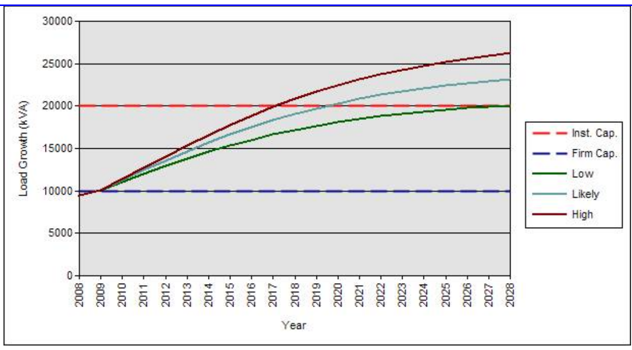
Data from the Eskom billing and Rustenburg Personnel was used to calculate the historical growth. The 2028 load values are the calculated forecast value due to the land use change forecast. Graphs showing the annual demand growth and installed transformer capacity are shown below.

Existing Transformer Load Substation / Description	Load Profile
System The System load comprise of the following Intake Substations: Industries, Voltaire and Kroondal. The Smelters load is excluded from Industries load.	
Voltaire 88/11kV Intake Substation Load 2008 – 17 MVA Load 2028 – 50MVA Firm Capacity – 20MVA Installed Capacity – 40MVA	
Kroondal 88/11kV Intake Substation Load 2008 – 17MVA Load 2028 – 37MVA Firm Capacity – 10MVA Installed Capacity – 20MVA	
Industries 88/33kV Intake Substation: The load comprise of the following 33/11kV substations: Boschdal, Donkerhoek, Park Geelhoutpark, Industries, Munic, and Noord. Smelters excluded. Load 2008 – 95MVA Load 2028 - 243MVA Firm Capacity – 120MVA Installed Capacity – 160MVA	

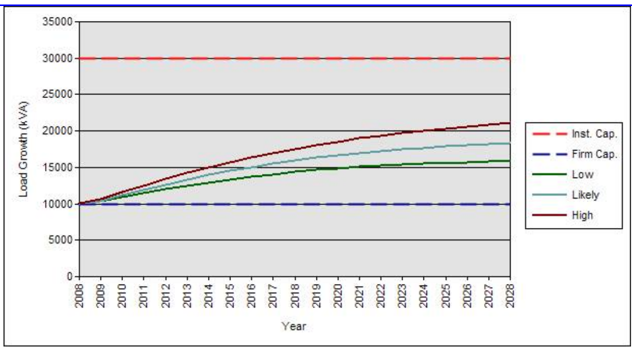
Industries 33/11kV Substation
Load 2008 – 22MVA
Load 2028 – 40MVA
Firm Capacity – 30MVA
Installed Capacity – 40MVA



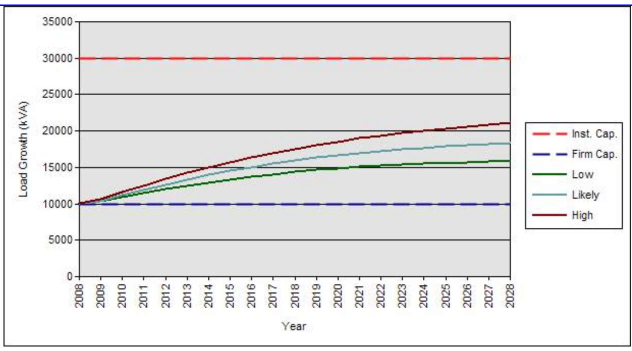
Donkerhoek 33/11kV Substation
Load 2008 – 9MVA
Load 2028 – 25MVA
Firm Capacity – 10MVA
Installed Capacity – 20MVA



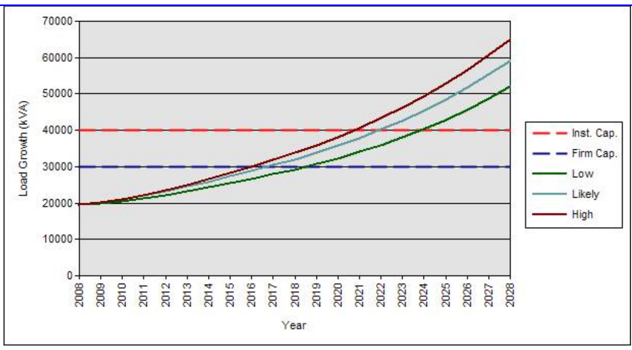
Geelhoutpark 33/11kV Substation
Load 2008 – 10MVA
Load 2028 – 21MVA
Firm Capacity – 10MVA
Installed Capacity – 30MVA



Noord 33/11kV Substation
Load 2008 - 6MVA
Load 2028 – 13MVA
Firm Capacity – 10MVA
Installed Capacity – 10MVA



Munic 33/11kV Substation
Load 2008 – 19MVA
Load 2028 – 65MVA
Firm Capacity – 30MVA
Installed Capacity – 40MVA



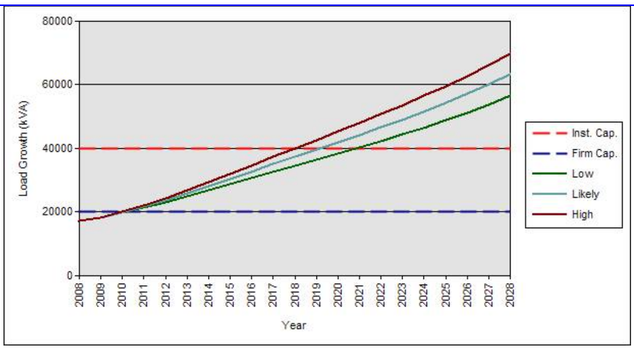
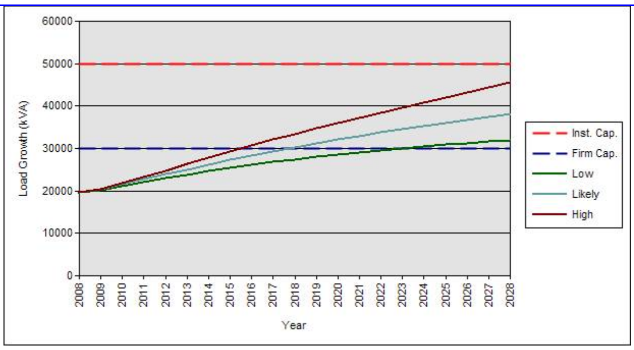
Boschdal 33/11kV Substation Load 2008 – 17MVA Load 2028 – 66MVA Firm Capacity – 20MVA Installed Capacity – 40MVA	
Park 33/11kV Substation Load 2008 – 19MVA Load 2028 – 39MVA Firm Capacity – 30MVA Installed Capacity – 50MVA	

Table 4-3: Rustenburg Expected Yearly Demand Growth

SUBSTATION	Firm kVA	Installed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
BOSCHDAL 33/11kV	20000	40000	17170	18035	19733	21628	23627	25824	28085	30366	32667	34968	37260	39542	41828	44139	46503	48954	51520	54228	57087	60095	63227
DONKERHOEK 33/11kV	10000	20000	9434	10126	11289	12451	13589	14681	15712	16671	17553	18356	19082	19735	20318	20839	21301	21711	22072	22390	22668	22912	23122
GEELHOUTPARK 33/11kV	10000	30000	10059	10404	11181	11930	12643	13313	13936	14511	15037	15516	15947	16335	16682	16990	17264	17498	17705	17886	18046	18188	18319
INDUSTRIES 33/11kV	30000	40000	21613	21887	22254	22670	23121	23683	24328	25033	25799	26622	27496	28422	29699	30999	32298	33573	34804	35971	37064	38075	39001
KROONDAL 33kV	10000	20000	17200	17724	18705	19740	20812	21996	23155	24306	25436	26531	27583	28586	29541	30452	31324	32165	32987	33798	34607	35422	36246
MUNIC 33/11kV	30000	40000	19484	20141	20937	22009	23194	24521	25894	27345	28871	30478	32060	33871	35810	37906	40190	42693	45443	48460	51750	55302	59085
NOORD 33/11kV	10000	20000	5871	5974	6267	6717	7121	7564	8043	8552	9087	9641	10205	10773	11337	11892	12432	12952	13447	13915	14354	14763	15142
PARK 33/11kV	30000	50000	19590	20307	21494	22691	23883	25055	26194	27294	28349	29357	30321	31241	32121	32964	33774	34555	35310	36045	36765	37474	38175
VOLTAIRE 33kV	20000	40000	16954	16386	18110	19831	21425	23105	24823	26573	28331	30010	31608	33154	34631	36029	37340	38562	39697	40746	41712	42605	43432
INDUSTRIES 33kV	160000	160000	127110	130723	136966	143677	150585	157832	165168	172563	179999	187448	194789	202252	209739	217281	224918	232689	240642	248814	257220	265851	274658

Table 4-4: Substation Transformer Firm / Installed Capacity Loading (including smelter on Industries)

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 Rustenburg.

5.1 Network Analysis

Network simulations were conducted on the existing and future Rustenburg networks. Network simulations included:

- Steady-state analysis. Analyses were conducted on various network load level and configurations to effectively identify thermal and voltage violations occurring due to existing and future load growth. Alternatives were identified and tested to ensure technical viable solutions to these violations.
- Selective contingency analysis was further carried out where a specific network element was taken out of service and the result thereof tested through a load flow. In order to relief voltage and flow violations identified during the contingency analysis, the addition or upgrade of network facilities was identified and tested technically.

Network analyses were grouped into three distinct time frames:

- Base year (2008/9),
- Short-term (2009-2012), and
- Longer-term (2012-2028).

The following sections provide high-level discussion and results obtained through the analysis of the Rustenburg network during these time frames.

5.2 Evaluation Discussion

Figure 5-1: Rustenburg shows the existing Eskom supply network around Rustenburg. The majority of the expected growth will take place through CBD densification as well as new development to the South-East limited by the Platinum corridor to the North and the Magaliesberg mountain range to the South.

Figure 5.2 gives a graphical indication of the existing and future loading in substation zones as well as the installed and firm transformer capacities.

With the Waterkloof Substation position fixed, possible Eskom supply points are indicated in Figure 5-3: Possible Eskom Supply Points

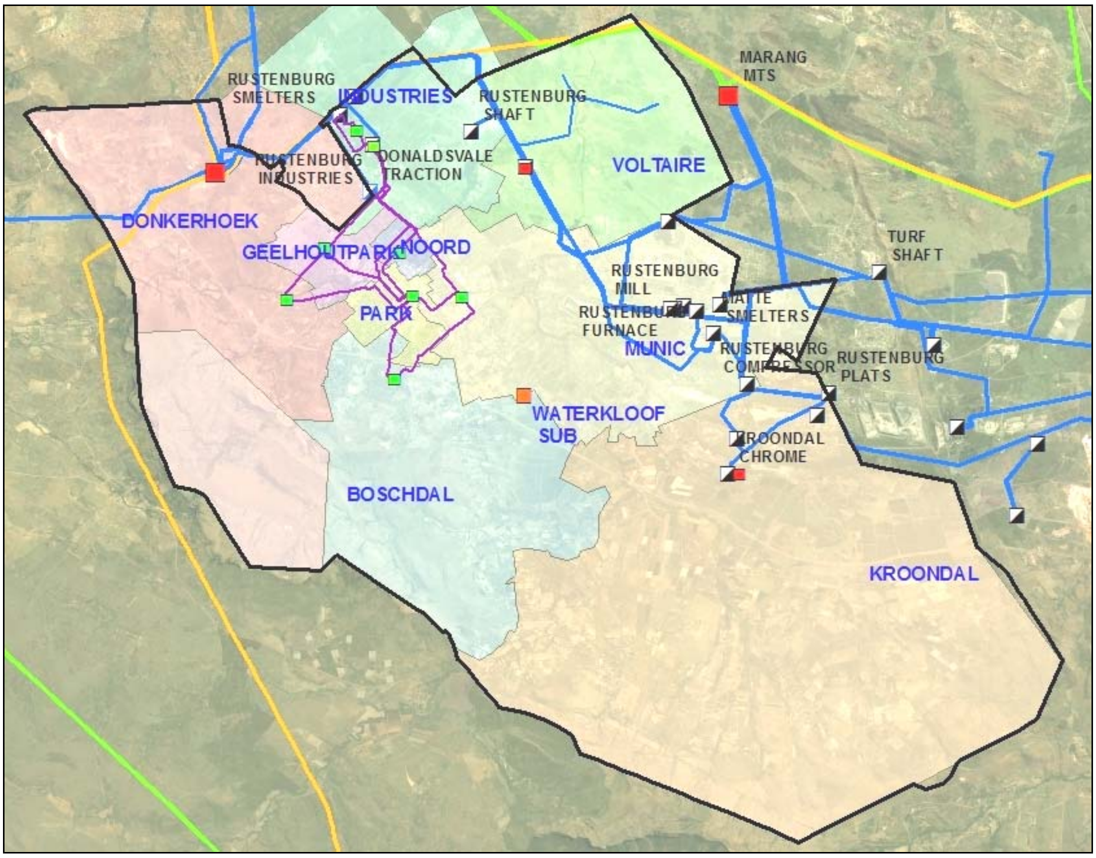


Figure 5-1: Rustenburg and Eskom Existing Networks

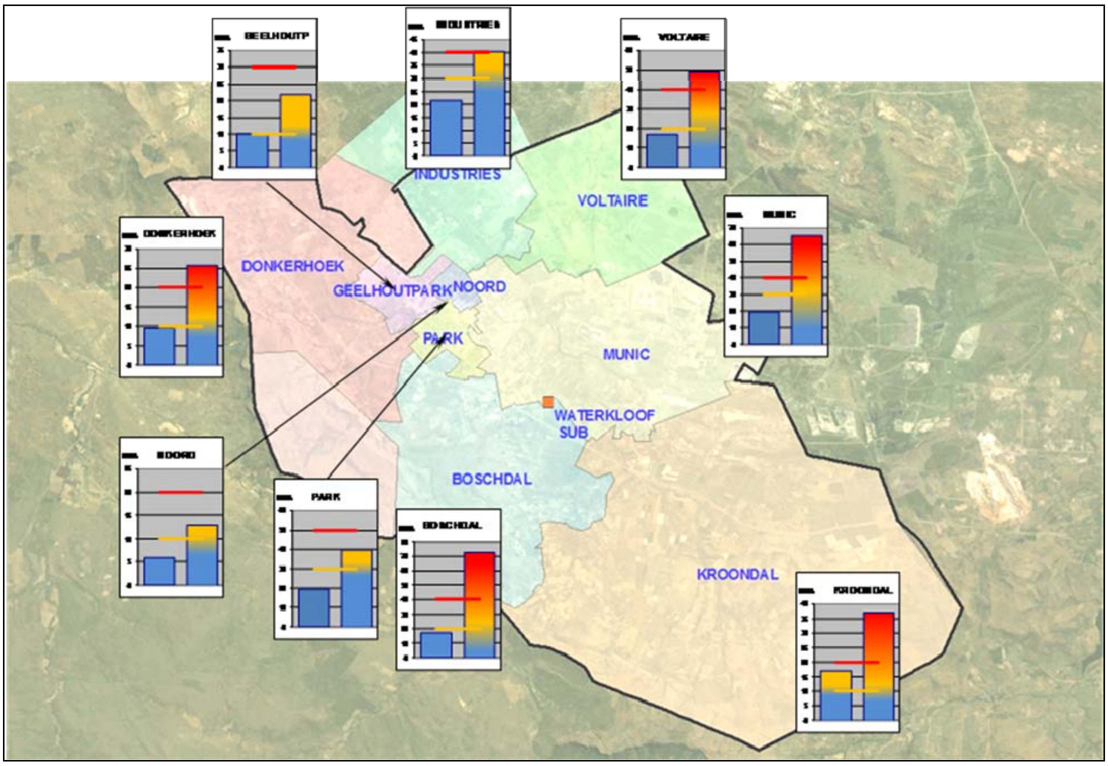


Figure 5-2: Loading on Existing Substation Zones

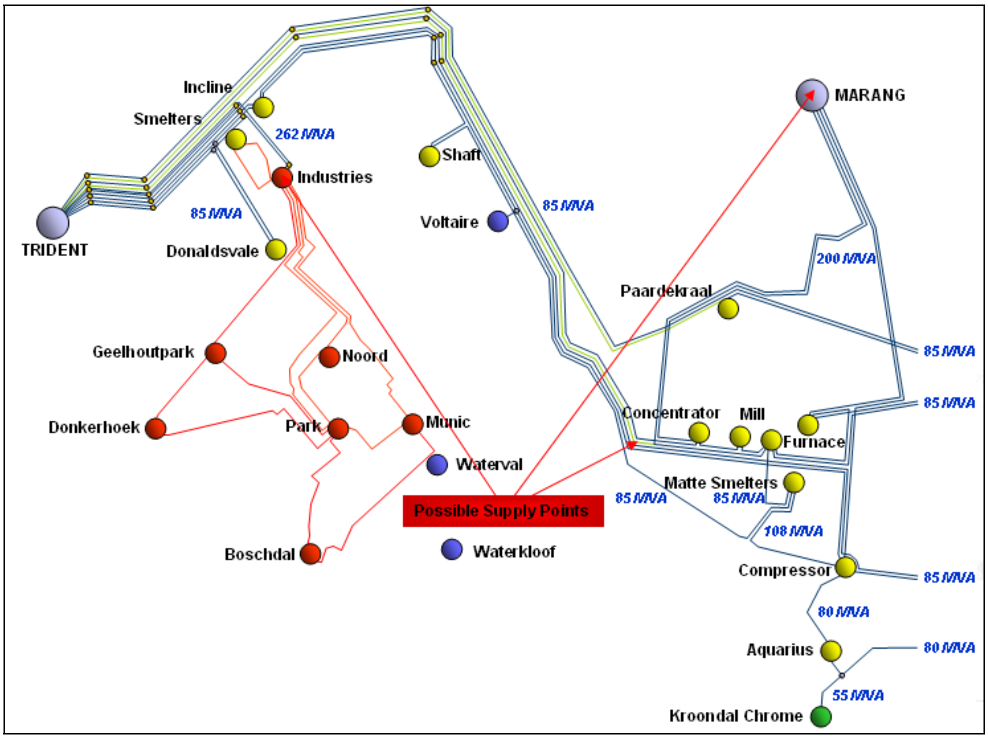


Figure 5-3: Possible Eskom Supply Points

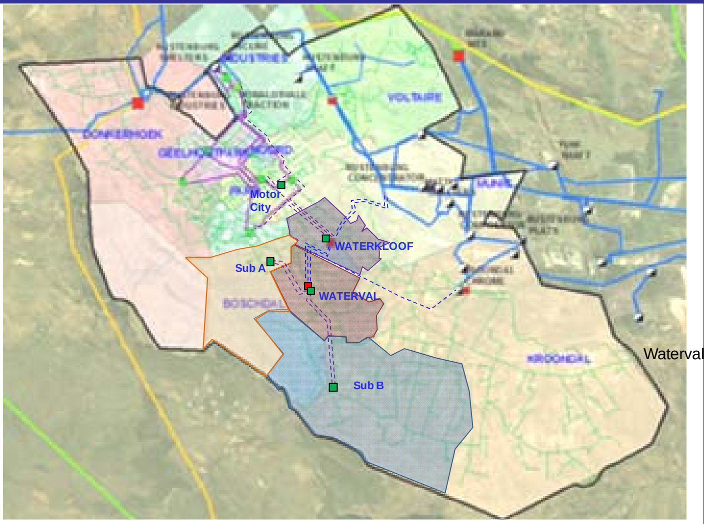
Eskom indicated that they can only supply directly from Marang Substation.

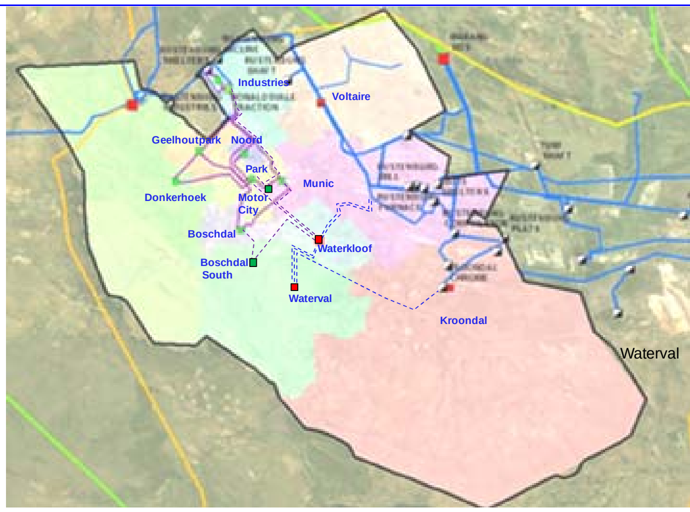
5.3 Scenario Development – 88kV Supply Options

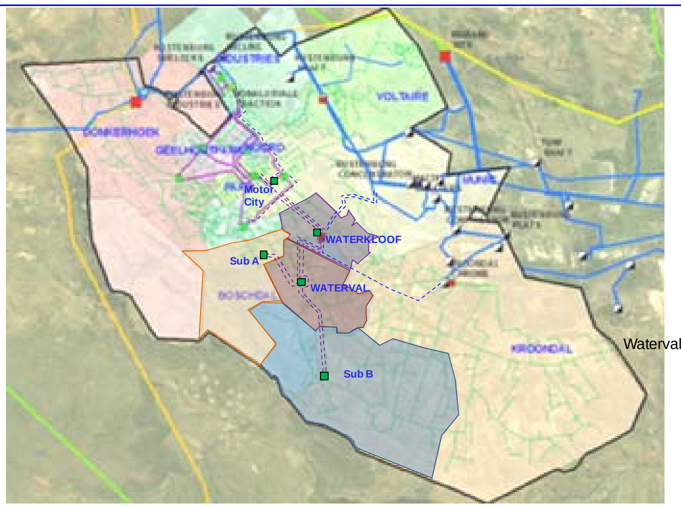
Various scenarios were created within which accounted for different supply options in the vicinity of the proposed new substations, these proposed scenarios were work shopped with representatives of Rustenburg and the most feasible options are highlighted below. This is discussed in detail in the Network Assessment Addendum to this report.

With the Industries intake point already over the 120MVA firm capacity, and encroaching the 160MVA installed capacity, it must be kept in mind to reduce the 88kV load at this Eskom intake point.

<table>
<tr><th>Options</th><th>Description</th><th>Image</th></tr>
<tr><td>Scenario 1</td><td>Scenario 1 includes a new 88/33kV Substation (Waterval) with three 33/11kV substations to take the load in the growth area.

Sub B can also take load from Kroondal to prevent Kroondal transformer upgrade in 2020.</td><td>
</td></tr>
<tr><td>Scenario 2</td><td>Scenario 2 includes a new 88/11kV Substation (Waterval) to supply the load in the major growth area.

Kroondal needs to be upgraded to 4x10MVA</td><td>
</td></tr>
<tr><td>Scenario 3</td><td>Scenario 3 requires the upgrade of Waterkloof to 3x80MVA with 33kV distribution from there.

Sub B can also take load from Kroondal to prevent Kroondal transformer upgrade in 2020.</td><td>
</td></tr>
</table>

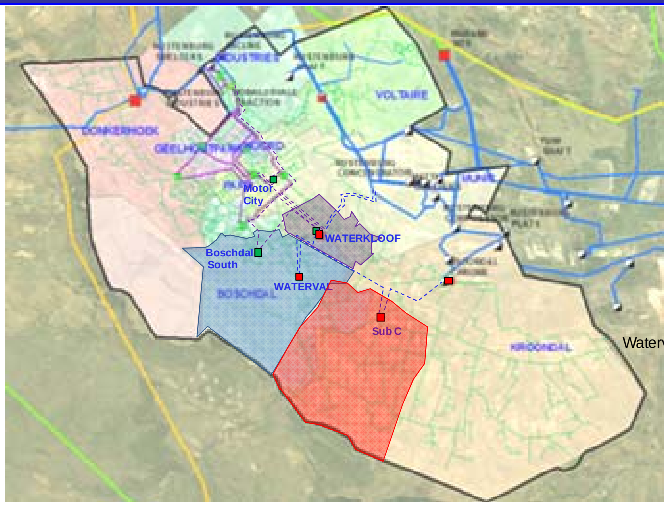
Options	Description	Image
Scenario 4	Scenario 4 includes twp 88/11kV substations, Waterval and Sub C. Boschdal South 33/11kV substation will take load from Boschdal. Sub C can also take load from Kroondal to prevent Kroondal transformer upgrade in 2020.	

Table 5-1: Supply Scenarios

5.4 Substation Development Cost

In order to obtain a financial comparison for the different scenarios, a budget cost estimate was done for the four options. The cost of Waterkloof Substation was omitted in all cases.

Options	Cost
Scenario 1	R 170 155 209
Scenario 2	R 101 120 827
Scenario 3	R 163 649 861
Scenario 4	R 114 427 314

Table 5-2: Substation Development Cost

Scenario 2 is the lowest cost solution

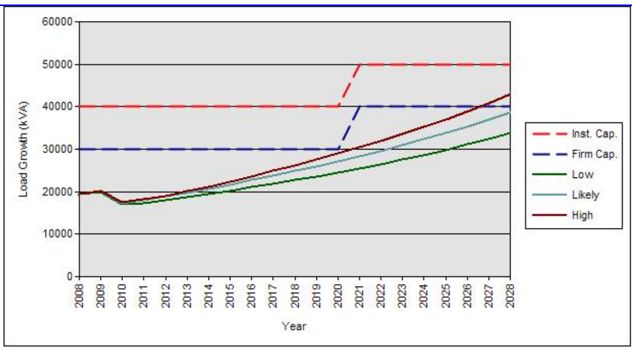
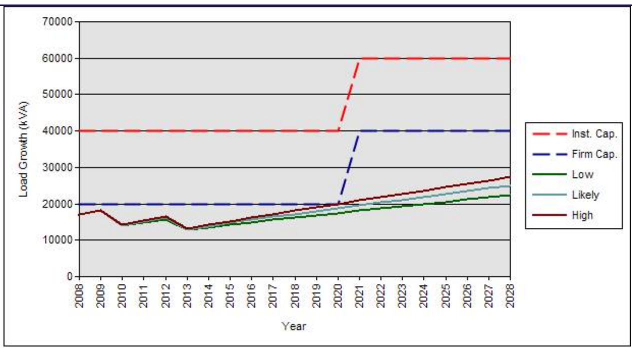
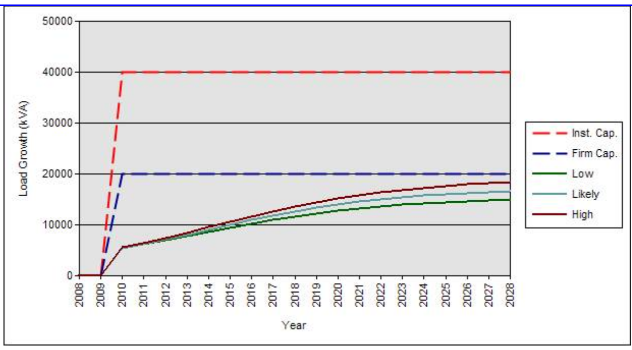
Technically, scenario 4 is the best solution. Mush less will be spend on 11kV infrastructure which may even out the financial difference.

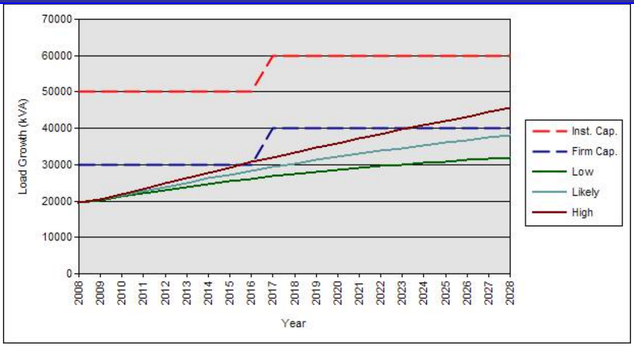
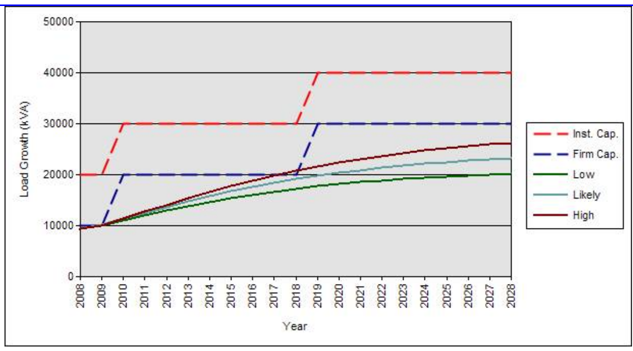
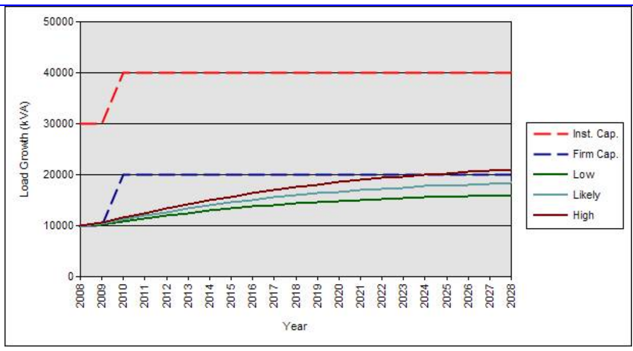
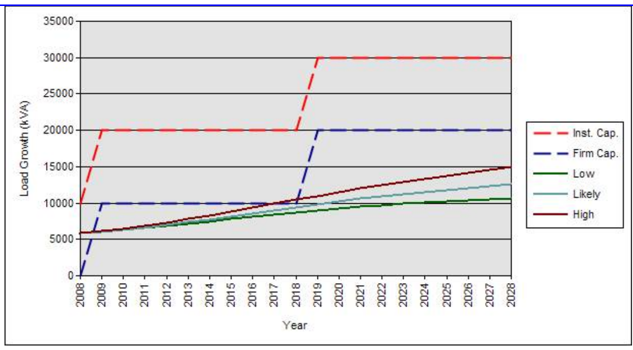
Scenario 4 is the preferred scenario and the detailed development plan was build round this option.

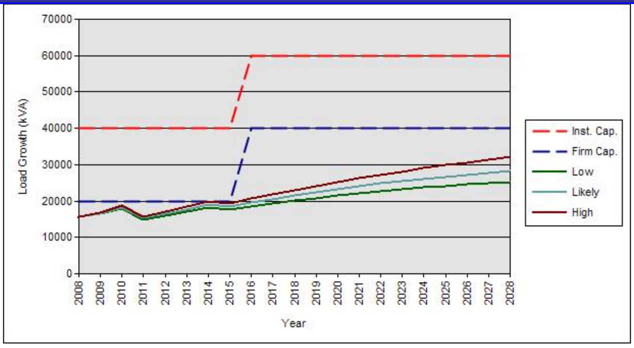
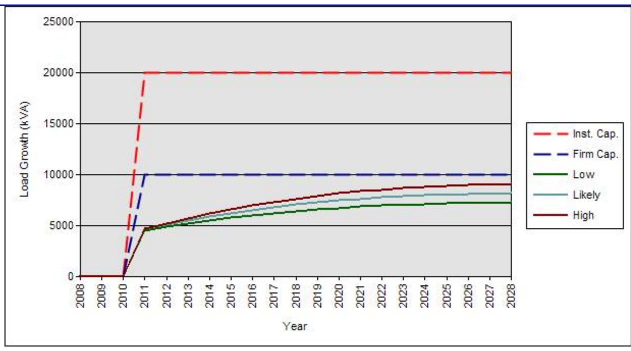
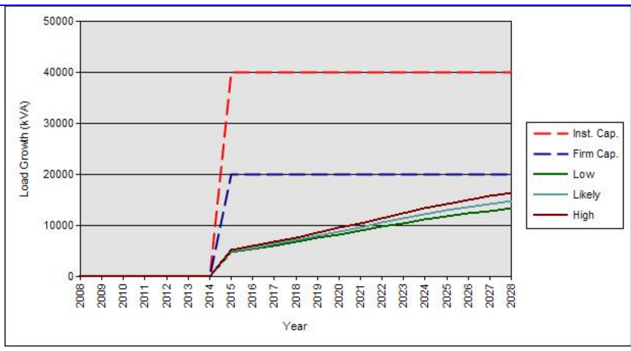
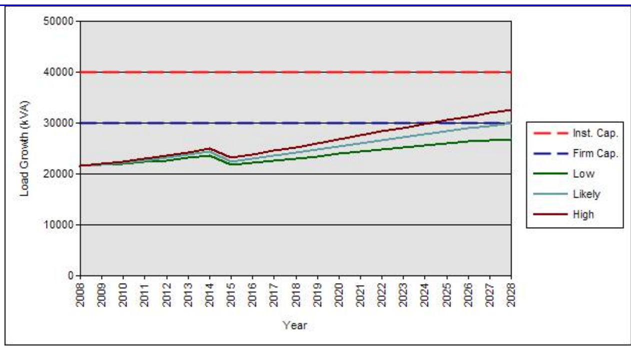
5.5 Network Assessment

5.5.1 Substation Planning

In this section, the loading on substation transformers is considered and the upgrade of transformers or the introduction of new transformers is assessed.

Scenario 4 – Future Transformer Load Substation / Description	Load Profile
<u>Kroondal Substation</u> 2010: Install 10MVA transformer no 3. 2011: Transfer 3MVA to Waterkloof 33/11kV 2014: Transfer load to 88/11kV Sub C.	
<u>Munic Substation</u> Proposed Projects: 2010: Transfer load to Waterkloof Substation 2021: Add 10MVA transformer no 5 (Already available on site)	
<u>Boschdal Substation</u> Proposed Projects: 2010: Build New 33/11kV 2x20MVA Boschdal South Substation (2010 Alternative: Install 20MVA trf no 3) 2013: Build Waterval 88/11kV Substation; Transfer load to Waterval Substation	
<u>Boschdal South Substation</u>	

Scenario 4 – Future Transformer Load Substation / Description	Load Profile
Park Substation Proposed Projects: 2017: Replace 10MVA trf with 20MVA trf	
Donkerhoek Substation Proposed Projects: 2010: Add 10MVA trf no 3 (from Geelhoutpark) (2010 Alt: Replace 2X10MVA trf with 2x20MVA trf.) 2019: Install 10MVA transformer no 4 (Transformer due for old age replacement) (2019 Alt: Feed from other 11kV Substations in contingency situation)	
Geelhoutpark Substation Proposed Projects: 2010: Replace 10MVA trf with 20MVA trf – 10MVA trf to Donkerhoek.	
Noord Substation Proposed Projects: 2009: Add 10MVA trf no.2 (Project completed) 2018: Add 10MVA trf no.3 if load growth follows Realistic or Optimistic path (2018 Alt: Feed contingency on 11kV from other substations if load growth follows pessimistic path or less.)	

Scenario 4 – Future Transformer Load Substation / Description	Load Profile
<u>Voltaire Substation</u> Proposed Projects: 2011: Build Magwasie 88/11kV 2x10MVA Substation 2015: Build Seraleng 88/11kV 2x20MVA Substation 2016: Install Voltaire 20MVA trf no 3 (10MVA trf will also do if available)	
<u>Magwasie Substation</u>	
<u>Seraleng Substation</u>	
<u>Industries Substation</u> Proposed Projects: 2015: Transfer load to Seraleng Substation	

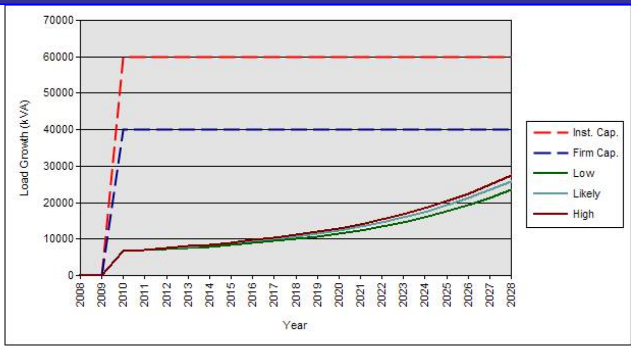
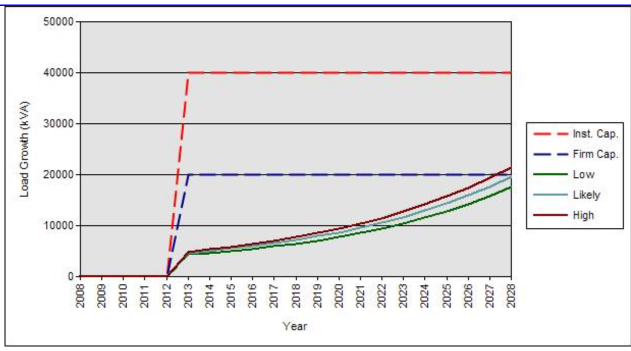
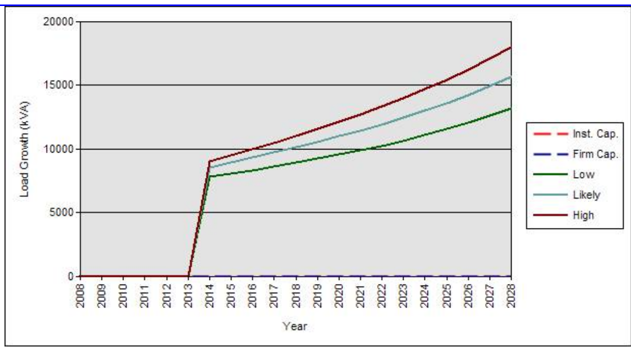
<table>
<tr><th>Scenario 4 – Future Transformer Load
Substation / Description</th><th>Load Profile</th></tr>
<tr><td><u>Waterkloof Substation</u>
Proposed Projects:
2010: Transfer load from Munic Sub to Waterkloof 88/11kV
2010: Feed Proposed Boschdal South Substation on 33kV
2010: Feed Boschdal 33kV Substation
2011: Feed Motor City 33kV Substation
2013: Feed Munic 33kV Substation
2014: Feed Park 33kV Substation
2014: Install 88/33kV trf no 3
2018: Install 88/33kV trf no 4</td><td>
</td></tr>
<tr><td><u>Waterval Substation</u>
Proposed Projects:
2013: Build 88/11kV 2x40MVA Substation. Transfer load from Boschdal Substation</td><td>
</td></tr>
<tr><td><u>Sub C Substation</u>
Proposed Projects:
2014: Build 88/11kV 2x20MVA
Take load from Kroondal and Boschdal substations</td><td>
</td></tr>
</table>

Table 5-3: Scenario 4 – Substation Assessment

Loading Table (Do-nothing Scenario)

SUBSTATION	Firm kVA	Installed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
BOSCHDAL 33/11kV	20000	40000	17170	18035	19733	21628	23627	25824	28085	30366	32667	34968	37260	39542	41828	44139	46503	48954	51520	54228	57087	60095	63227
DONKERHOEK 33/11kV	10000	20000	9434	10126	11289	12451	13589	14681	15712	16671	17553	18356	19082	19735	20318	20839	21301	21711	22072	22390	22668	22912	23122
GEELHOUTPARK 33/11kV	10000	30000	10059	10404	11181	11930	12643	13313	13936	14511	15037	15516	15947	16335	16682	16990	17264	17498	17705	17886	18046	18188	18319
INDUSTRIES 33/11kV	30000	40000	21613	21887	22254	22670	23121	23683	24328	25033	25799	26622	27496	28422	29699	30999	32298	33573	34804	35971	37064	38075	39001
KROONDAL 33kV	10000	20000	17200	17724	18705	19740	20812	21996	23155	24306	25436	26531	27583	28586	29541	30452	31324	32165	32987	33798	34607	35422	36246
MUNIC 33/11kV	30000	40000	19484	20141	20937	22009	23194	24521	25894	27345	28871	30478	32060	33871	35810	37906	40190	42693	45443	48460	51750	55302	59085
NOORD 33/11kV	10000	20000	5871	5974	6267	6717	7121	7564	8043	8552	9087	9641	10205	10773	11337	11892	12432	12952	13447	13915	14354	14763	15142
PARK 33/11kV	30000	50000	19590	20307	21494	22691	23883	25055	26194	27294	28349	29357	30321	31241	32121	32964	33774	34555	35310	36045	36765	37474	38175
VOLTAIRE 33kV	20000	40000	16954	16386	18110	19831	21425	23105	24823	26573	28331	30010	31608	33154	34631	36029	37340	38562	39697	40746	41712	42605	43432
INDUSTRIES 33kV	160000	160000	127110	130723	136966	143677	150585	157832	165168	172563	179999	187448	194789	202252	209739	217281	224918	232689	240642	248814	257220	265851	274658

Proposed Loading Table

SUBSTATION	Firm kVA	Installed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
BOSCHDAL 33/11kV	40000	60000	17170	18113	14107	15112	16167	13009	13817	14702	15550	16391	17219	18028	18818	19593	20357	21118	21881	22652	23433	24222	25013
DONKERHOEK 33/11kV	30000	40000	9434	10155	11320	12486	13626	14720	15753	16714	17598	18404	19132	19787	20374	20897	21363	21776	22141	22462	22743	22990	23202
GEELHOUTPARK 33/11kV	20000	40000	10059	10404	11181	11930	12643	13313	13936	14511	15037	15516	15947	16335	16682	16990	17264	17498	17705	17886	18046	18188	18319
INDUSTRIES 33/11kV	30000	40000	21613	21889	22257	22673	23148	23723	24375	22481	23020	23590	24187	24802	25429	26058	26680	27289	27878	28441	28977	29485	29964
KROONDAL 33kV	20000	30000	17189	17713	16420	17465	18548	19742	13068	13855	14618	15342	16018	16637	17196	17695	18134	18517	18851	19139	19390	19608	19799
MUNIC 33/11kV	40000	50000	19484	20135	17337	18002	18848	19741	20692	21687	22718	23781	24872	25993	27147	28343	29592	30904	32291	33763	35323	36967	38686
NOORD 33/11kV	20000	30000	5871	5982	6283	6613	6970	7354	7758	8177	8603	9029	9447	9850	10234	10596	10934	11248	11541	11814	12071	12313	12545
PARK 33/11kV	40000	60000	19590	20307	21494	22691	23883	25055	26194	27294	28349	29357	30321	31241	32121	32964	33774	34555	35310	36045	36765	37474	38175
VOLTAIRE 33kV	40000	60000	15598	16509	18209	15285	16434	17667	18948	18467	19536	20535	21470	22371	23228	24034	24786	25484	26132	26734	27294	27816	28310
WATERKLOOF 88/33kV	120000	160000	0	0	5112	5928	24606	38697	66149	69868	73514	77093	80583	83970	87259	90460	93595	96692	99775	102872	105999	109165	112359
WATERKLOOF 88/11KV	40000	60000	0	0	6741	7072	7456	7914	8379	8883	9432	10039	10718	11487	12367	13382	14555	15911	17468	19239	21229	23425	25806
BOSCHDAL SOUTH 33/11KV	20000	40000	0	0	5381	6240	7151	8096	9053	10001	10917	11784	12585	13311	13956	14519	15004	15415	15759	16045	16280	16472	16625
SUB C 88/11KV	20000	40000	0	0	0	0	0	0	9515	9948	10385	10827	11279	11745	12230	12740	13281	13860	14480	15148	15866	16635	17452
MAGWASIE	10000	20000	0	0	0	5105	5560	5993	6398	6772	7112	7416	7684	7918	8120	8291	8436	8557	8658	8740	8803	8854	8895
SERALENG	20000	40000	0	0	0	0	0	0	0	5372	6089	6878	7737	8643	9581	10534	11481	12404	13284	14105	14859	15536	16137
INDUSTRIES 33kV BUS	120000	160000	127110	130828	114731	119263	106056	109911	88854	88514	90859	93123	95297	97370	99336	101186	102918	104522	106006	107373	108630	109785	110847

Table 5-4: Scenario 4 – Substation Transformer Firm / Installed Capacity Loading

5.5.2 Network Planning

The Network Assessment and Planning results are summarized below. Detailed year – by – year development is discussed in the Network Assessment Addendum.

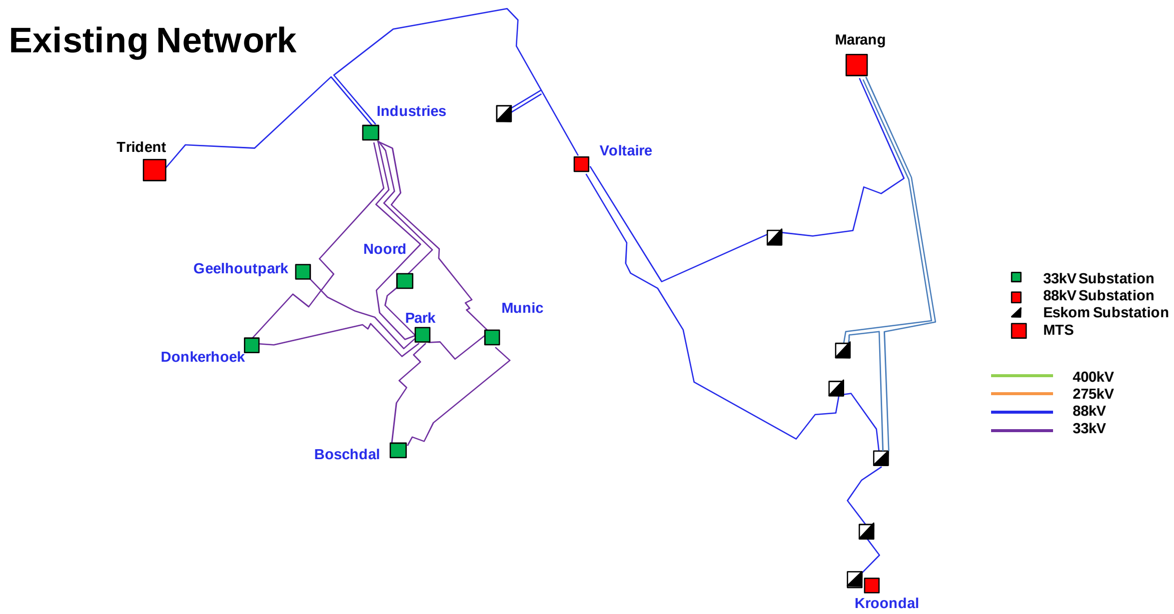


Figure 5-4: Existing Electrical Network

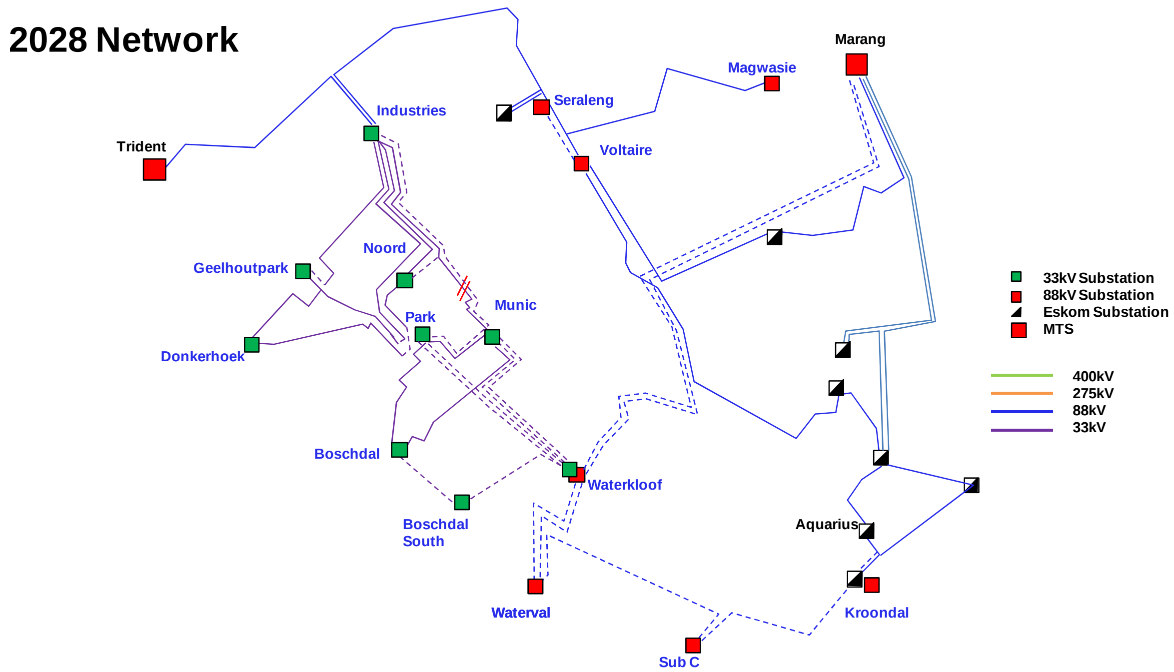


Figure 5-5: Proposed 20 year Electrical Network

With the new substation and network configuration, a large portion of the infeed from Eskom is transferred from Industries to Waterkloof/Marang to remain within the Industries supply limit. The figures below describe how the yearly demand at the different intake points changes.

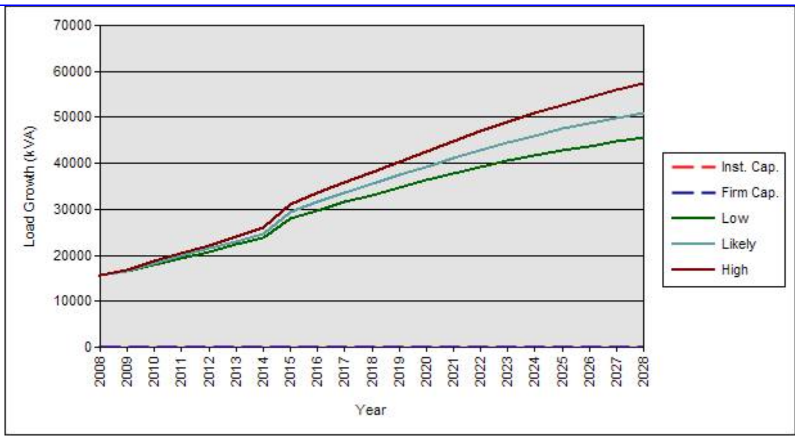
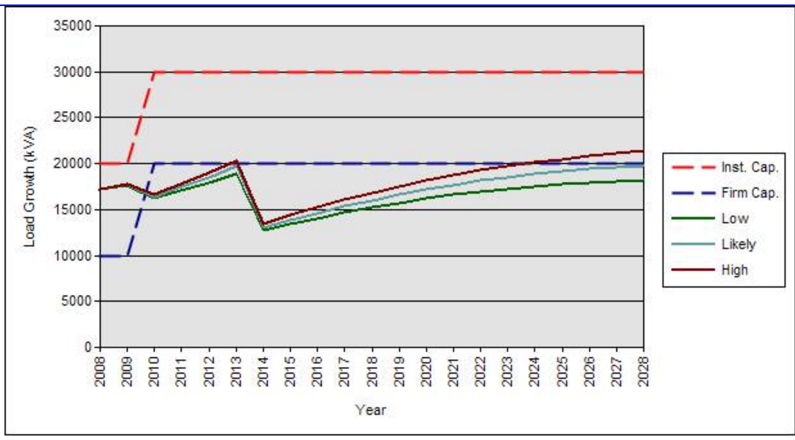
<table>
<tr><th>Infeed Name</th><th>20 year Demand</th></tr>
<tr><td>Industries
(Existing configuration – smelter included)</td><td>
</td></tr>
<tr><td>Voltaire</td><td>
</td></tr>
<tr><td>Kroondal</td><td>
</td></tr>
</table>

Table 5-5: Eskom Intake change over 20 years

5.5.3 Proposed 20 year Substation Zoning

With the addition of the new substations over the planning period, the substation supply zones will change. The proposed zoning is shown in Figure 5-6: Proposed 20 year Zoning.

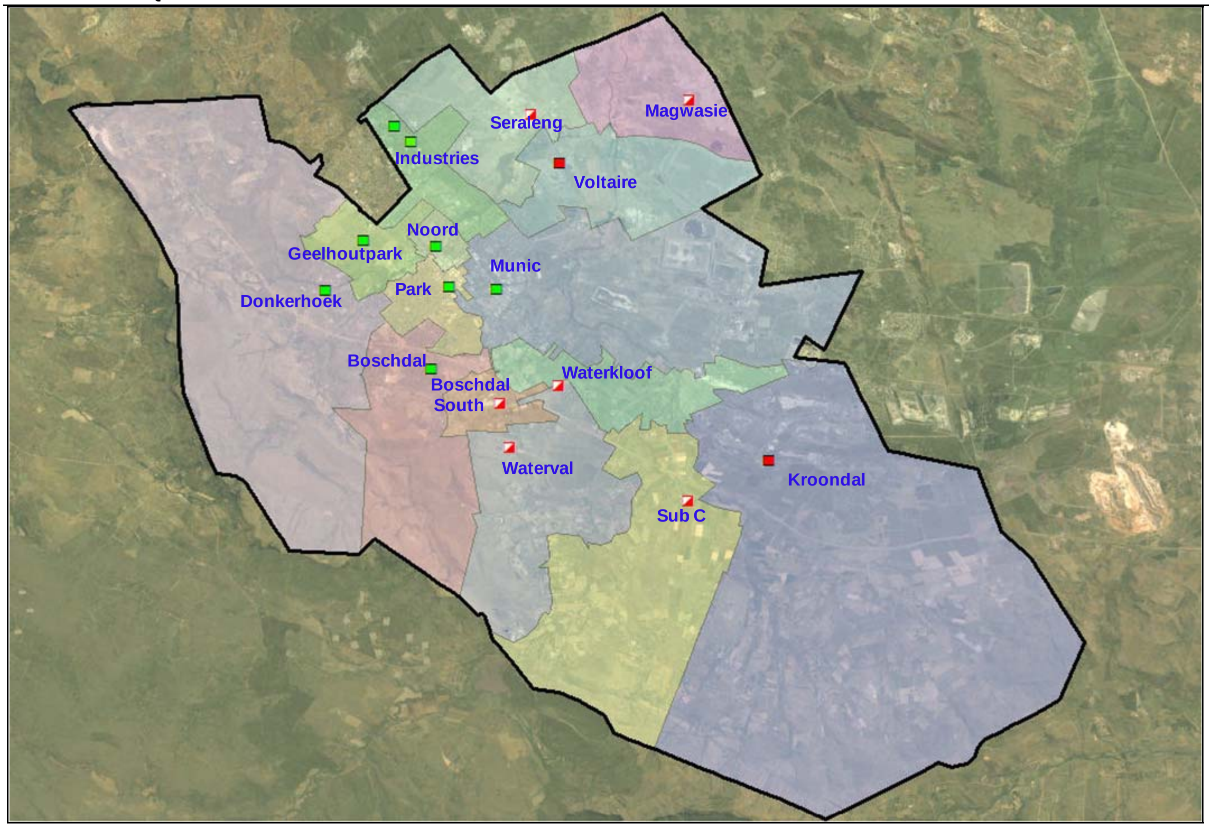


Figure 5-6: Proposed 20 year Zoning

6 Capital Program

6.1 Background

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

  The impact on future cash flows,

  Net present worth of the investments

6.2 Costing of Capital Projects

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

- Expansion requirements, and
- Network security requirements.

The costing of capital projects were done 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.

These scenarios evaluate:

- The Supply Options,
- Distribution network Development, and
- Refurbishment Requirements.

The Project lists for Strenghtening and Refurbisment projects are liated below.

No	Planned Year	Substation	Project Name	Project Description	Tot Cost (xR1000)
8	2009	33kV Network	Industries - Park	Install line and 2x240mm² cables Industries - Munic - Motor City - Park	19,849
9	2009	Waterkloof	Waterkloof	New Substation, 2 x 88/33kV, 40MVA Transformers.	24,742
10	2009	Noord	Noord	Add 33/11kV 10MVA trf no 2 (Completed)	6,564
11	2010	88kV Network	Waterkloof - Eskom 88kV Line	New 2 x 88kV, 200MVA, 13.4km Line (Single Structure) from Waterkloof to Marang 88kV Infrastructure.	36,648
14	2010	Boschdal South	New Boschdal South Substation	Build 33/11kV 2x20MVA substation	22,838
15	2010	33kV Network	Supply to Boschdal South	Install 2x240mm² cables from Waterkloof to Boschdal South	17,745
16	2010	Geelhoutpark	Geelhoutpark	Replace 33/11kV 10MVA Trf with a 20MVA. Relocate transformer to Donkerhoek substation.	11,137
17	2010	Waterkloof	Waterkloof	Add 3 x 88/11kV, 20MVA Transformers. Expand 2 x 88kV Bay and 11kV Switchgear.	32,552
18	2010	Kroondal	Kroondal	Install 10MVA transformer no 3	8,832
19	2010	33kV Network	Boschdal	Expand Boschdal 1 x 33kV Switchgear for Cable from Waterkloof.	1,328
20	2010	33kV Network	Boschdal South - Boschdal 33kV Cable	New 2 x 33kV, 240mm² from Boschdal South to Boschdal Substation.	8,399
21	2010	Donkerhoek	Donkerhoek	Add 1 x 33/11kV,10MVA Transformer from Geelhoutpark. Expand 1 x 33kV and 1 x 11kV Switchgear.	3,018
33	2011	Magwasie	Magwasie 88/88kV Substation	Build Magwasie 88/11kV 2x10MVA substation on existing 88kV line	25,903
34	2012	33kV Network	Waterkloof - Munic 33kV Cable	New 4 x 33kV, 240mm² 4.0km Cable from Waterkloof to Munic Substation.	30,542
39	2012	33kV Network	Munic	Expand Park 1 x 33kV Switchgear for Cables from Waterkloof.	1,328
40	2013	Geelhoutpark	Geelhoutpark Connection	Add 1 x 33kV, 500mm²/1C/Cu, 0.1km Cable from Geelhoutpark-T to Geelhoutpark Substation.	293
44	2013	88kV Network	Waterval - Waterkloof	Build 4.2km 1x100MVA line from Waterkloof to Waterval and add 88kV feeder at Waterkloof	10,900
45	2013	Waterval	Waterval	Build 88/11kV 2x20MVA Substation	34,909
46	2014	33kV Network	Park	Expand Park 1 x 33kV Switchgear for Cables from Waterkloof.	1,328
47	2014	33kV Network	Waterkloof - Park 33kV Cable	New 2 x 33kV, 240mm² 4.6km Cables from Waterkloof to Park Substation.	17,562
48	2014	Sub C	Build 88/11kV Sub C	Build 88/11kV 2 x 20MVA substation	29,794
49	2014	88kV Network	88kV lines Waterval - Sub C	Build 88kV 100MVA line Waterval - Sub C - Kroondal 9.5km	15,574
50	2014	88kV Network	Kroondal - Aquarius T line	Build second line Kroondal - Acquarius T 0.95km	3,978
52	2014	Waterkloof	Waterkloof	Add 1 x 88/33kV, 40MVA Transformer. Expand 1 x 88kV Bay.	8,675
53	2015	Seraleng	New Seraleng 88/11kV Sub	Build Seraleng 88/11kV 2x20MVA substation	26,307
54	2015	33kV Network	Noord-Industries T	Install 500mm² cable from Noord to Industries/Munic T	4,260
55	2015	88kV Network	Supply to Seraleng	Build 88kV line in servitude from Voltaire 1.8km Wolf conductor	2,123
57	2016	Voltaire	Voltaire	Add 1 x 88/11kV, 20MVA Transformer no 3. Expand 1 x 88kV Bay and 1 x 11kV Switchgear.	11,133
58	2017	Park	Park	Replace the 33/11kV 10MVA transformer with a 20MVA transformer.	5,692
59	2018	Noord	Noord	Install 33/11kV 10MVA trf no 3	6,564
62	2018	Waterkloof	Waterkloof	Add 1 x 88/33kV, 40MVA Transformer. Expand 1 x 88kV Bay.	8,675
65	2021	Munic	Munic	Install 33/11kV 10MVA trf no 5.	8,080

Table 6-1: Strenghtening Capital Project List

No	Planned Year	Substation	Project Name	Project Description	Tot Cost (xR1000)
1	2008	Alpha	Alpha - 11kV Switchgear	Replace - The 11kV switchgear consists of 5 panels, with 5 Sprecher & Schulh circuit breakers.	
2	2008	Amie Coetzee	Amie Coetzee - 11kV Switchgear	Replace - The 11kV switchgear consists of 6 panels [1968], with 4 Johnson & Phillips circuit breakers and 2 Johnson	
3	2008	Bravo	Bravo - 11kV Switchgear	Replace - The 11kV switchgear consists of 9 panels [1971], with 8 AEG circuit breakers.	
4	2008	Charlie	Charlie - 11kV Switchgear	Replace - The 11kV switchgear consists of 5 panels [1972], with 5 AEG circuit breakers.	
5	2008	Huis Voster	Huis Voster - 11kV Switchgear	Replace - The 11kV switchgear consists of 8 panels [1961], with 3 AEG circuit breakers, 3 English Electric circuit	
6	2008	Koorsboom	Koorsboom - 11kV Switchgear	Replace - The 11kV switchgear consists of 16 panels [1972], with 16 Vanossi circuit breakers.	
7	2008	Munic	Munic - 33kV Isolators	Replace - The 33kV Capacitor Isolators [3] need to be replaced.	
12	2010	Industries Refurb	Industries - 33kV Refurbishment	Replace - Replace all 33kV Outdoor equipment and Yard [excluding the Transformer bays].	9,086
13	2010	Swembad	Swembad - 11kV Switchgear	Replace - The 11kV switchgear consists of 10 panels [1971], with 10 Reyrolle Parsons [SF6l] circuit breakers.	2,471
22	2011	Boomstraat	Boomstraat - 11kV Switchgear	Replace - The 11kV switchgear consists of 5 panels [1953], with 2 isolator links and 3 circuit breakers.	1,236
23	2011	Booster	Booster - 11kV Switchgear	Replace - The 11kV switchgear consists of 4 panels [1957], with 2 Johnson & Phillips isolator links and 2 Johnson &	989
24	2011	Christie	Christie - 11kV Switchgear	Replace - The Megnafix switching unit is very old [1969], passes its useful life expectancy and must be replaced.	274
25	2011	Kameelboom	Kameelboom - 11kV Switchgear	Replace - The 11kV switchgear consists of 7 panels [1978], with 6 AEG circuit breakers and 1 AEG isolator link.	1,730
26	2011	Middel	Middel - 11kV Switchgear	Replace - The 11kV switchgear consists of 4 panels [1968], with 2 AEG circuit breakers and 2 AEG isolator links.	989
27	2011	MKTV	MKTV - 11kV Switchgear	Replace - The 11kV switchgear consists of 4 panels [1964], with 1 Johnson & Phillips circuit breaker and 3 Johnson	989
28	2011	Ou Waterwerke	Ou Waterwerke - 11kV Switchgear	Replace - The 11kV switchgear consists of 12 panels [1973], with 11 Johnson & Phillips circuit breaker and 1	2,966
29	2011	Paardekraal	Paardekraal - 11kV Switchgear	Replace - The 11kV switchgear consists of 3 panels [1986], with 1 Reyrolle Parsons circuit breaker and 2 Reyrolle	741
30	2011	Poskantoor	Poskantoor - 11kV Switchgear	Replace - The 11kV switchgear consists of 5 panels [1960], with 1 Johnson & Phillips circuit breaker and 4 Johnson	1,236
31	2011	Tambuti	Tambuti - 11kV Switchgear	Replace - The switching unit is very old [1969], passes its useful life expectancy and must be replaced.	247
32	2011	Unicorn	Unicorn - 11kV Switchgear	Replace - The Megnafix switching unit is very old [1970], passes its useful life expectancy and must be replaced.	274
35	2012	Geelhoutpark Refurb	Geelhoutpark - 11kV Switchgear	Replace - The 11kV switchgear consists of 22 panels [1981], with 22 Asea circuit breakers.	5,437
36	2012	Moepel	Moepel - 11kV Switchgear	Replace - The 11kV switchgear consists of 6 panels [1972], with 5 Johnson & Phillips circuit breakers and 1 Johnson	1,483
37	2012	Pick a PaY	Pick a Pay - 11kV Switchgear	Replace - The 11kV switchgear consist of 10 panels [1971].	2,471
38	2012	Safari Tuine	Safari Tuine - 11kV Switchgear	Replace - The 11kV switchgear consists of 11 panels [1975], with 10 Johnson & Phillips circuit breakers and 1	2,718
41	2013	Kloof	Kloof - 11kV Switchgear	Replace - The 11kV switchgear consists of 7 panels [1974], with 5 Johnson & Phillips circuit breakers and 2 Johnson	1,730
42	2013	Lilac	Lilac - 11kV Switchgear	Replace - The 11kV switchgear consists of 8 panels [1975], with 7 Johnson & Phillips circuit breakers and 1 Johnson	1,977
43	2013	Wisteria	Wisteria - 11kV Switchgear	Replace - The 11kV switchgear consists of 11 panels [1975], with 3 GEC [SF6], 7 Johnson & Phillips circuit breakers	2,718
51	2014	Industries 33kV	Industries - 33kV Switchgear		5,488
55	2015	Park 33kV	Park - 33kV Switchgear		3,763
59	2017	Geelhoutpark Refurb	Geelhoutpark - 33kV Switchgear		3,068
60	2017	Donkerhoek 33kV	Donkerhoek transformer upgrade	Replace - The 33/11kV, 10MVA with new 33/11kV, 20MVA transformer (was due for replacement - age)	5,692
62	2019	Donkerhoek 33kV	Donkerhoek - 33kV Switchgear		2,352
63	2021	Boschdal 33kV	Boschdal - 33kV Switchgear		2,003
65	2024	Munic 33kV	Munic - 33kV Switchgear		2,666

Table 6-2: Refurbishment Project List

NETGroup

R x 1000	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	TOTAL (RM)
Kroondal	-	-	8,832	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8,832
Munic	-	-	-	-	-	-	-	-	-	-	-	-	-	8,080	-	-	-	-	-	-	-	8,080
Boschdal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Park	-	-	-	-	-	-	-	-	-	5,692	-	-	-	-	-	-	-	-	-	-	-	5,692
Geelhoutpark	-	-	11,137	-	-	293	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,430
Noord	-	6,564	-	-	-	-	-	-	-	-	6,564	-	-	-	-	-	-	-	-	-	-	13,127
Voltaire	-	-	-	-	-	-	-	-	11,133	-	-	-	-	-	-	-	-	-	-	-	-	11,133
Industries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waterkloof	-	24,742	32,552	-	-	-	-	-	-	-	17,351	-	-	-	-	-	-	-	-	-	-	74,644
Waterval	-	-	-	-	-	34,909	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34,909
Donkerhoek	-	-	3,018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3,018
Sub C	-	-	-	-	-	-	29,794	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29,794
Magwasie	-	-	-	25,903	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25,903
Boschdal South	-	-	22,838	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22,838
Seraleng	-	-	-	-	-	-	-	26,307	-	-	-	-	-	-	-	-	-	-	-	-	-	26,307
88kV Network	-	-	36,648	-	-	10,900	19,552	2,123	-	-	-	-	-	-	-	-	-	-	-	-	-	69,223
33kV Network	-	19,849	27,473	-	31,871	-	18,890	4,260	-	-	-	-	-	-	-	-	-	-	-	-	-	102,343
TOTAL	-	51,154	142,497	25,903	31,871	46,102	68,236	32,690	11,133	5,692	23,914	-	-	8,080	-	-	-	-	-	-	-	447,272

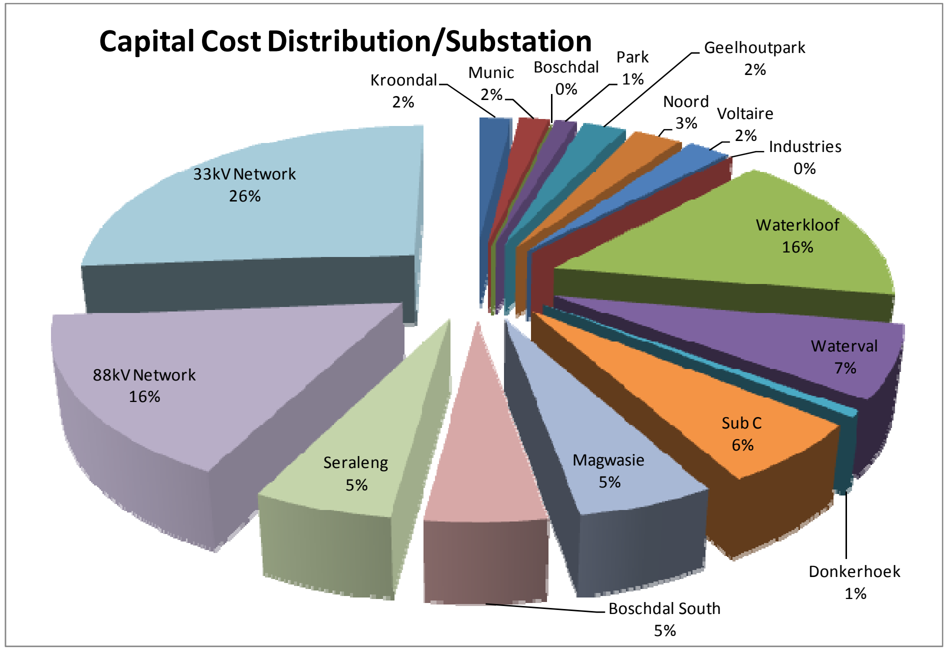


Table 6-3: Cost Distribution per Substation

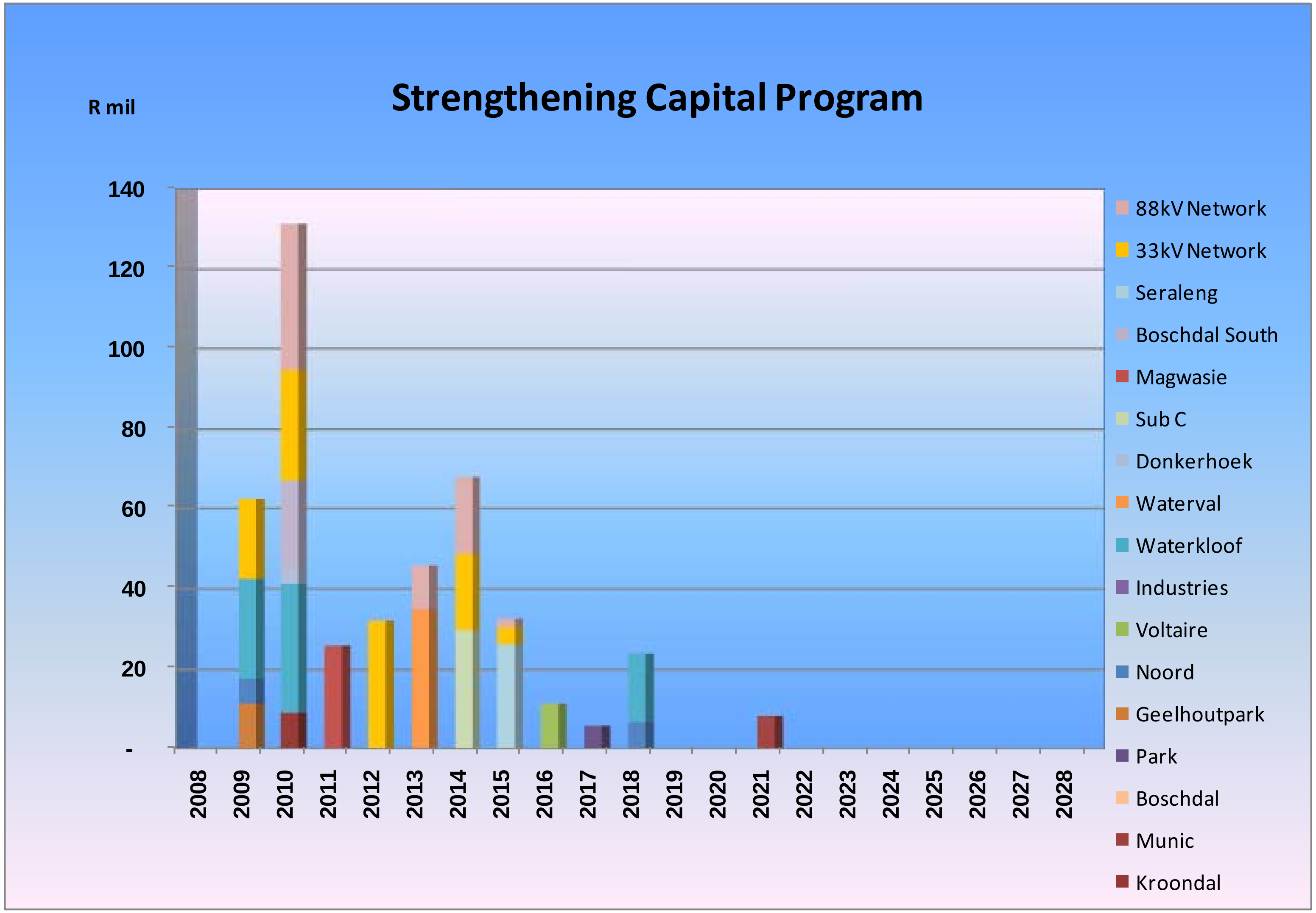
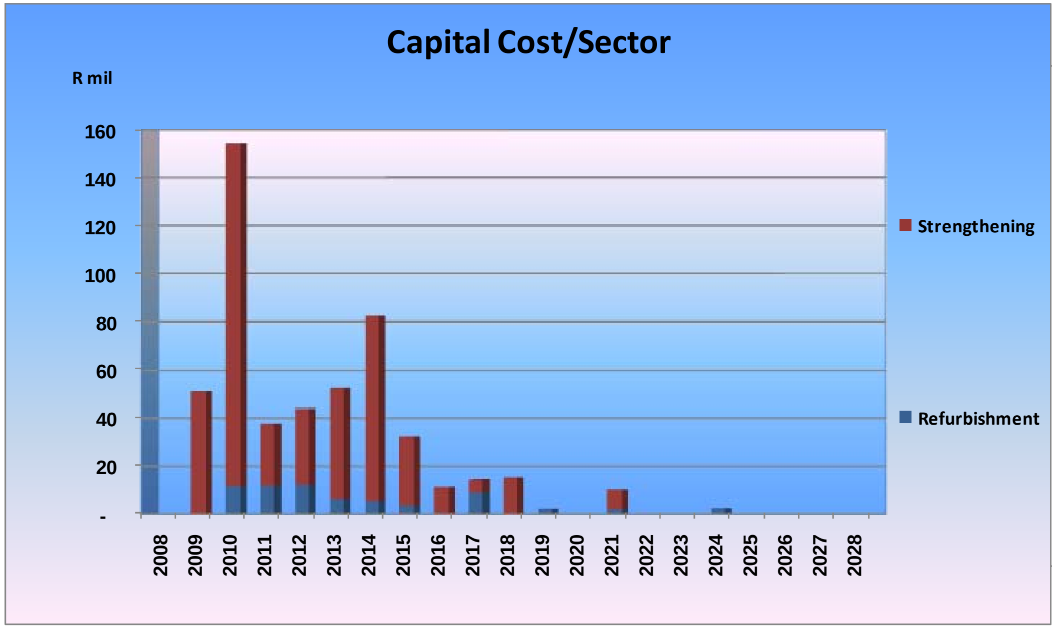


Table 6-4: Strenghtening Capital Program

R x 1000	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	TOTAL (RM)
Refurbishment	-	-	11,557	11,670	12,110	6,425	5,488	3,763	-	8,760	-	2,352	-	2,003	-	-	2,666	-	-	-	-	66,794
Strengthening	-	51,154	142,497	25,903	31,871	46,102	76,911	32,690	11,133	5,692	15,239	-	-	8,080	-	-	-	-	-	-	-	447,272
TOTAL	-	51,154	154,054	37,573	43,980	52,528	82,399	36,453	11,133	14,452	15,239	2,352	-	10,083	-	-	2,666	-	-	-	-	514,067



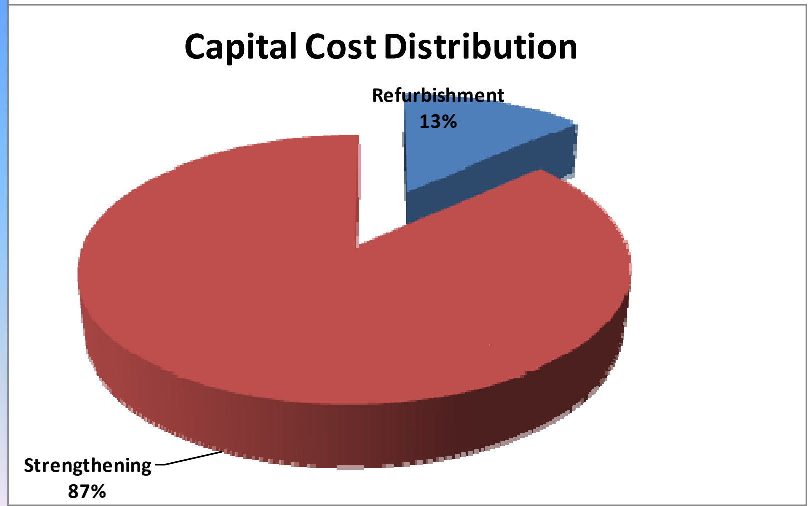


Table 6-5: Refurbishment and Strengthening Cost Comparison

7 Addendums:

Addendum A: Network Assessment