Lüderitz Town Council

Electrical Distribution and Renewable Energy Masterplan

2024 and beyond

bicon namibia

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1 Foreword

The Lüderitz Electrical Masterplan 22/33 - 24/25 has initially been compiled and presented by the masterplan team, in line with the ToR (Term of Reference). **Since nothing is as dynamic and as permanent as change**, the trends observed over the last 2 years, especially the interest to Lüderitz, related to the Green Hydrogen Revolution, Transport Hub, and Oil Industry Service Centre, necessitated a request to update the already compiled and documented report. The revised structure plan, as enclosed by SPC, presents additional infeed to the center of the project. The work is undertaken by a team of project stakeholders and project participants –

The project team is grateful to the competent assistance of Lüderitz Town Council employees on all levels for their support providing the essential data and references, the support during the site surveys and providing the relevant statistical and administrative information for the master plan.

1.1 Acknowledgements

A special appreciation is attributed to the **Lüderitz Town Council** for their assistance and contribution to various projects to make the masterplan a success, in terms of the requirement to make their town a vibrant hub in the region. -

Town Planners and Spatial Development Plans in reference, are limited and backdated. No state of the reference documents in that context could be obtained.

Also acknowledged is information from NamPower on statistical and historical data as relevant, as well as source data for load-flow simulations.

Without the dedicated contribution of each team player, the project would not be able to be a success to Lüderitz Town Council and stakeholders – It is the aspiration of the project team, that the Lüderitz Electrical Masterplan 22/33 - 24/25 will succeed in paving the way for a continued stable, sustainable network, and accelerated development and electrification of the PSA (Progressive Settlement Areas) and informal settlement areas around the town in the peri-urban area, where an intense pressure is being articulated to pursue with electrification projects and to bring electricity and power to the people, in line with government's NDP3, Harambee and vision 2030.

The dynamics of the master plan as flexible document allows for future manipulation of data, simulations, and economic and financial models, which are provided as part of the project, to ensure the master plan can adapt to all scenarios and circumstances as they are changing.

1.2 Challenge

As no updated Planning Structure plan is on hand, the developmental forecast wrt. Infrastructure and bulk infrastructure requirements are challenging but have been accommodated as far as possible in the planning, based on historic and related objectives.

Introduction

2 Introduction

Lüderitz Town Council embarked on an Electrical Masterplan in its license area for supply and distribution. The ToR (Terms of Reference) to which BICON Inc. has been appointed, entailed the provision of an Electrical Masterplan for the Town. **This included, amongst others upgrade paths, RE (Renewable Energy Policies) and support, Guidance to PV and Embedded Generation, MSBM participation and others**.

The key drivers for the electrical infrastructure masterplan are to keep track of the fast growing and dynamic industry. Lüderitz Town Council is challenged to remain a key catalyst for development in Namibia, especially in the northern regions, in view to attain government's ambitious goals as defined, amongst others in the vision 2030 document. – Lüderitz Town Council 's mission statement ***aims to supply quality and affordable electricity to all its customers*** must be fulfilled.

Lüderitz Town Council must cater for the envisaged ever rapid-growing demand in term of energy requirement – should this materialize, as key ingredient to all industrial commercial and social, socio-economic as well as all business activities – Lüderitz Town Council is to be well positioned, with fully operating, metering, maintenance, and support structures in place in the town, to implement a master-plan guideline.

Energy, Power, Electricity – must be provided in an adequate and accessible manner, reliable and at an elevated level of QoS (Quality of Supply) and Service.

2.1 Project objectives and ToR (Terms of Reference)

The ToR (Terms of Reference) has been prepared by the Lüderitz Town Council and the LTC management team.

This is in reference to the Consulting Engineers' ToR (terms of Reference) and SoW (Scope of Works).

The project objectives are to prepare an MV (Medium Voltage 11kV) Electricity distribution masterplan for **Lüderitz**, which is implementable, sustainable, and realistic, considering the current constraints. The envisaged realistic timeframe planned for is 10 (ten) years, as further predictions would be too speculative.

On the technical aspect, Lüderitz Town Council must be presented with a hands-on guideline to facilitate the MV (Medium Voltage 11kV) system expansion to also improve the OM (Operations and Maintenance), to ensure an electrical distribution system to a reliable, safe, and efficient with minimal losses.

To ensure a good understanding of the deliverables attained, an inception meeting was held at Lüderitz Town Council offices to clarify all deliverables. These are attached in Appendix 10.

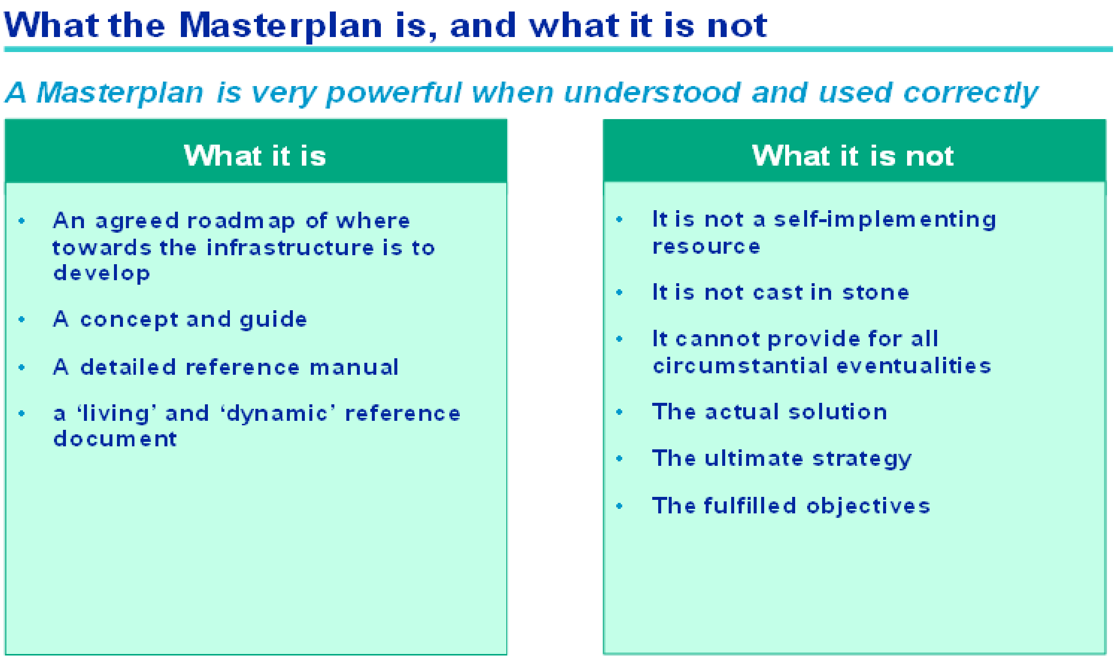
A masterplan is very powerful when understood and used correctly:

- A Master plan IS.
  - a guide
  - a '**living' and 'dynamic'** reference document
- A masterplan is NOT:
  - the actual solution
  - the ultimate strategy
  - the fulfilled objectives

As per BICON Engineers Inc.' approach, the Lüderitz Electrical Masterplan 22/33 - 24/25 is a dynamic process.

With the self-motivated approach of the Lüderitz Town Council 's management committee it was possible to have a parallel approach to the masterplan, and the implementation of immediate remedial action tasks were facilitated, to date with success that has already averted further problems.

Figure 1 :What the Master plan is.

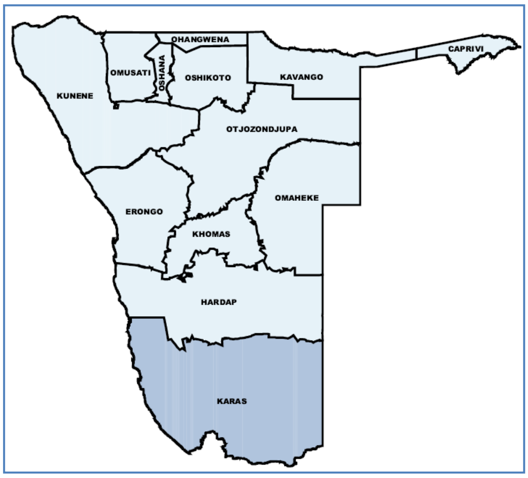


Whilst during the master plan significance is placed on mainly the technical and operational aspect of the distribution system, the following vital components must be addressed –

- Infrastructure components – upgrade paths, and development strategies to cater for load nodes and development centers.
- RE- (Renewable Energy) / Connection Policies/ Renewable Energy options for Lüderitz
- Infrastructure performance enhancement components
- Metering and Billing aspects – evolvement of the ORM (Operating and Reporting Manual) and TD (Tariff Determination) aspects for the town
- Sustaining / Implementation of an AMR (Automatic Meter Reading) system
- Electrification Extension components for the PSA (Progressive Settlement Areas) – limited discussion will focus on this aspect.
- Financial and economic analysis on network – infrastructure and electrification - limited

Ultimately the masterplan must present a tool and solution and PIP (Project Implementation Plan) that is implementable both technically and financially (economic). Set milestones must be benchmarked and evaluated on a regular (annual) basis on achievement, progress, and network performance. –

2.2 Regional reference –



The Karas region, with Lüdertiz as gateway to the Atlantic Ocean, has been experiencing accelerated growth over the last few years. – as indicated due to –

- Energy Sector
- Hs2, Oil, Gas
- Transport Sector/logistics.
- Oil Industry Service/repair center.
- Energy Infeed, Energy Development – National Grid (NamPower) MSBM.

Key variables are mining (and to a limited extend fishing) and tourism activities in the areas.

Lüderitz is a regional development and growth hub attracting development both nationally and internationally. The recent interest in the following related project by key players being –

- NAMPOWER
- HYPHEN

Are of reference. This is related to the new Wind-Energy Park in the area as well as the Green Hydrogen Development. The latter is of such magnitude, **that it's not possible to accommodate the impact in the masterplan, since this is several quantum's larger in size and magnitude**, that it's not considerable at this stage.

Situated on the coast (south-western) of Namibia this growing town is set to become the hub of trade and development in the south.

Historic projects such as the acclaimed Phosphate plants did not materialize. – the Forecast and accuracy of key developmental nodes make a major impact on planning parameters and are not exactly foreseen.

Further at steady influx of people from the region to the town into the informal areas creates a big demand and need for access to electricity. The town is in the fortunate position having been supported by the government formalizing key informal areas – of e.g. Ext 8 on the eastern part of the town – Electrical infrastructure development can hence be conducted properly based on an available (formalized) format.

Both socio-economic and political pressure is being exerted – direct or indirect – to Lüderitz Town Council, to make electricity available. – LTC (Lüderitz Town Council) in terms of its license condition, is required to supply electricity, based on technical viable option, and payment (actual cost) of the infrastructure. –

2.3 Approach – Framework

- Detailed proposal and SoW (Scope of Works) definition, as conducted during 2022.
- Inception Meeting with stakeholders – outlining Lüderitz Town Council 's intention of the master plan, getting the required 'buy-in' and co-ownership of the master plan – esp. wrt. development projects, network upgrades, need for densification of the urban area, electrification of the peri-urban informal settlement areas, accommodation of fishing industry.
- Detail Site survey and data acquisition of existing infrastructure, mainly available information assimilated.
- Lüderitz Town Council consultation / inception meeting / consultative stakeholder meetings – implementation plan, business plan.

- Mapping and Drawings (as-built drawings).
- Renewable Energy Options- Wind, Solar, Biomass[1] and other
- Load forecast based on a wide data and resource spectrum acquired.
- Load-flow based on existing network infrastructure.
- Town-planners info – spatial development plan considerations for future town expansions.
- Financial Model – Economic assessment of the masterplan for:
- Part 1 (Infrastructure component)
- Prioritization of projects identified –
- Reporting summary

2.4 Major master-plan components

Hence the electrical masterplan has major project components, -

- Town Electrical Master-plan – to **facilitate the backbone infrastructure for the existing town**, to support the growing demand and to always ensure redundancy – i.e. a safe and secure supply – this component remains the responsibility of Lüderitz Town Council as license-holders. A critical analysis of the network is undertaken, and a systematic and prioritized re-enforcement plan for implementation is outlined.
- **Network** (capacity) **improvement** is analyzed in terms of DSM (Demand Site Management), in particular Ripple control systems. Power-factor correction and load shedding/shifting are considered and impacts on the ToU (Time of Use) tariffs implemented must be analyzed.
- **Renewable Energy Masterplan** and recommendations and results for the short-term benefit of Lüderitz.
- Town **Electrification and Expansion Masterplan**, to have a project plan to include and to facilitate electrification projects in the PSA (Progressive Settlement Areas) and informal settlement areas – this project part remains a national (regional) responsibility for financing, but the technical realization remains with Lüderitz Town Council as license-holder, and possibly for Lüderitz Town Council as co-financier. Development of all areas – i.e. all zones as outlined per spatial land use approach for business, commerce, industry, institutional, and high to medium income residential area, remain the responsibility of the developer, government, or town council. -
- Economic and financial overview for the two project parts above – considering the realistic implementation plan, guidelines, norms, and acceptable and appropriate concepts, are covered in the third project part. From the outlined and available ORM (Operating and Reporting Manual) as described by the ECB (Electricity Control Board), a rigid framework is laid on tariffs via the TD (Tariff Determination) model. – The tariffs have however to ensure that a long-term sustainable network and development is in place. The masterplan facilitates methodologies thereto.

[1] Refer to specific RE masterplan 2022.

2.5 Lüderitz Overview

2.5.1 History

It was founded in 1883 when Heinrich Vogelsang purchased Angra Pequena and some of the surrounding land on behalf of Adolf Lüderitz, a *Hanseat* from Bremen in Germany, from the local Nama chief. Lüderitz began its life as a trading post, with other activities in fishing and guano-harvesting. In 1909, after the discovery of diamonds nearby, Lüderitz enjoyed a sudden surge of prosperity. Today, however, diamonds are mostly found elsewhere and offshore, and Lüderitz has lost a lot of this interest.

The harbour has a very shallow rock bottom, making it unusable for modern ships; this led to Walvis Bay becoming the center of the Namibian shipping industry. Recently, however, the addition of a new quay has allowed larger fishing vessels to dock at Lüderitz. The town has also re-styled itself in an attempt to lure tourists to the area, which includes a new waterfront area for shops and offices.

The town is known for its colonial architecture, including some Art Nouveau work, and for wildlife including seals, penguins, flamingos and ostriches. It is also home to a museum and to the Lüderitz Speed Challenge, and formerly lay at the end of a railway line to Keetmanshoop.[2]

2.5.2 Administrative and Socio Demographic

Lüderitz is a fast-growing town – with fully fledged regional government offices, health, education, regional council offices, police, fishery, research, banks, shopping centers, hospitals, logistic centers etc.

A key factor is the harbor (Namport) as well as the fishing industry. – Tourism is contributing increasingly to the economic sphere of the town,

The national 2001 population and housing census for Namibia indicate an urban population of 12,900 with 3,217 households. Access to electricity is rated at 25.5% of households. [3] Assuming a realistic growth of 6% on the population (average) over the last 10 years – the population will currently be approximately 20-25,000 within the order of 5,600 households. A national census was held in 2025 – and predictions can be verified. The influx of people affects the numbers in terms of population and housing (without electricity) significantly. The formal reported figure is 16,125 persons.

[2] http://en.wikipedia.org/wiki/L%C3%BCderitz

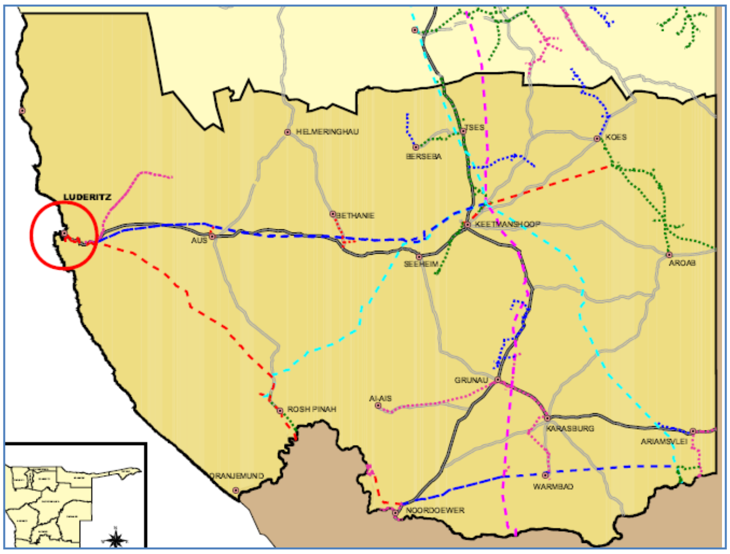
[3] 2001 Population and housing census, Karas / Verbal feedback BICON 2024/06

The 2024 census, for which no detail data has been released, but preliminary -indicates a growth of 77,000 to 109,000 inhabitants within the Karas Region, -it can be expected that the urbanization drive and sectoral shift, would align with a 30% growth in the town's population, mainly in informal settlement areas.

As from 2017/18 the energy aspect presented headlines with the first NamPower 5MW Wind Park.

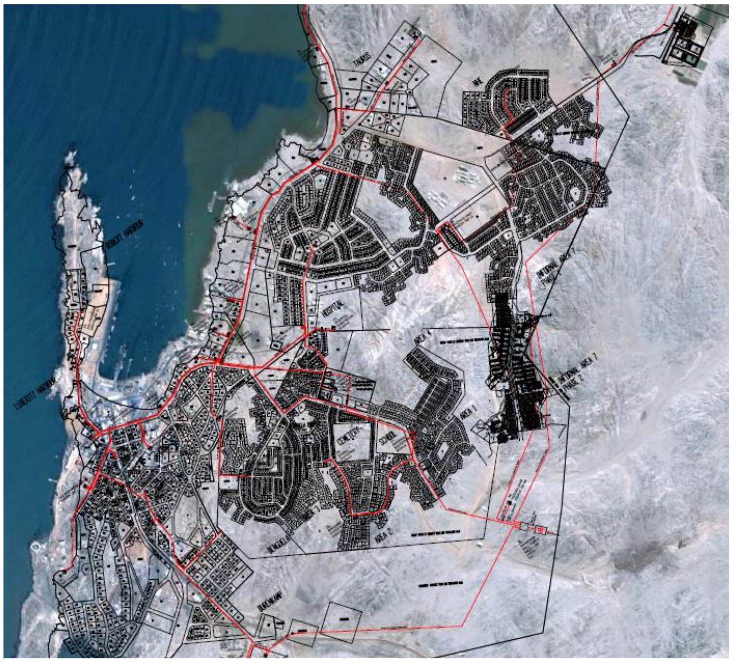
Current Green Hydrogen – Hyphen options present immense opportunities, risks, challenges- to be addressed. Further oil and offshore resources will complement the development of the electrical infrastructure.

Figure 2 :Karas overview –



The Lüderitz town, with revised town boundaries, will include parts of area 8 and area 7. An additional extended town boundary is envisaged in the medium-term future.

Figure 3 :Lüderitz aerial view with erf overlay overview –



Network Infrastructure Distribution Development Plan

CHAPTER SUMMARY:

Network Infrastructure Distribution Development Plan

The existing network characteristic and performance was assessed. – Sever short term short-comings were revealed which is addressed in the network expansion plan.

Different load density zones were defined for planning purposes, attaching both an ADMD (After Diversity Maximum Demand) as well as a COST per unit to each zone.

Based on this information, both an overall prediction for load and development cost has been established.

Load-growth prediction (Energy): - 2.5% p.a. (NEGATIVE Energy) . up to 2022 . + 5% as from 2023.2035

Load-growth prediction (Demand): - 2.5% p.a.(NEGATIVE DEMAND/FIXED DEMAND) . up to 2022 **. + 5% as from 2023.2035**

Town Demand reaches 7 MVA 2030 (NamPower system upgrade to 20 MVA required – only if WIND/Embedded Generation will be implemented) Note: Demand could increase faster if some key projects as outlined materialize.

Current Max. Demand (July 2020-21) 7.0 MVA

Load-factor Approx 50-56%

Installed DIVERSIFIED load 30 MVA …

Short term projects (PSA) not on hand / delayed 2.5-3.5 MVA (depends on development funding), anticipated accelerated 5-10MW capacity

Prioritised network extensions Complete ring-feeds and re-enforce central town feeder, Feeders to CBD (Central Business District) / industrial areas / fishing industry / NamPort and future PSA (Progressive Settlement Areas), Future Wind park, Ringfeed – Abalone Industrial Area – new structure plan, industrial area.

Network Philosophy CBD (n-3), Critical loads (n-2), non-critical (n-1), radial approach to network expansion policies, create second ring around town.

A load-flow study on DiGSILENT was performed to assess voltage profiles and current (fault) levels.

A protection philosophy (time grading) is proposed for implementation. Currently Protection Safety and coordination Issues are pertaining, affecting the operation of the network under Earth Fault condition.

Future [additional] 66kV in-feed is **not required in the foreseeable future** – this would be appropriate once the growth would approach 20-30 MVA – currently the proposed Lüderitz Town Council Lüderitz main intake station is located centrally and optimal.

Upgrade plans and technical issues are outlined – 20-25 upgrade projects, prioritised over the next 5 years are listed. – Capital expenditure of 50-100 Million is estimated.

The current QoS (Quality of Supply) of the town is adequate and acceptable and LTC has implemented an Incomer QoS online Portal as well as check-metering.

3 Electrical Master-plan – Network and Infrastructure Development Plan

3.1 Overview

The Town Electrical Master-plan's key objective is to facilitate the implementation of a proper (sustainable) backbone infrastructure for the existing town, to support the growing demand and to always ensure redundancy – i.e. a safe and secure supply This component remains the responsibility of Lüderitz Town Council as license-holder. A critical analysis of the network is undertaken, and a systematic and prioritized re-enforcement plan for implementation is outlined.

- The existing network performance and capability is assessed –
- An upgrade and short-term action plan for remedial action is proposed.
- Network (capacity) improvement is analyzed in terms of DSM (Demand Site Management), in particular Ripple control systems and PF correction.

3.1.1 <u>Technical</u>

Guidelines for implementation

- <u>As-Is</u> findings (of the existing network)
- <u>To-Be</u> status (ideal status in the long term)
- Work required to reach <u>To-Be</u> status and remedial measures
- Cost estimates for required work (<u>To-Be</u> status)
- Drawings (MV supply / distribution system)
- Load forecasting details (1-5-10 year prediction perspective)

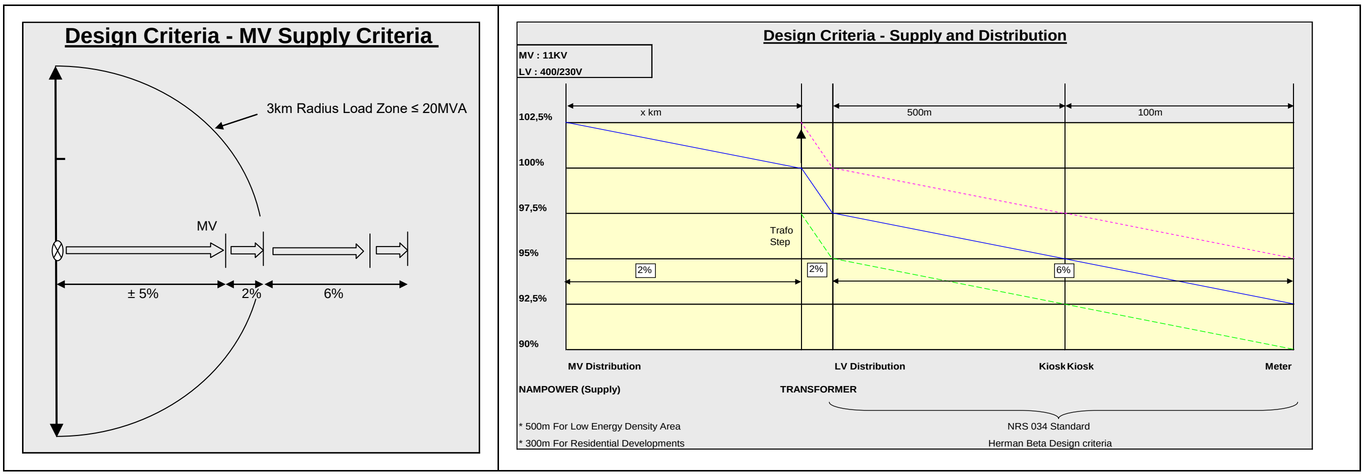
3.2 Network Philosophy, Redundancy and Reliability analysis –

3.2.1 <u>Network Design Philosophy</u>

Load supply capabilities and voltage profiles are key issues.

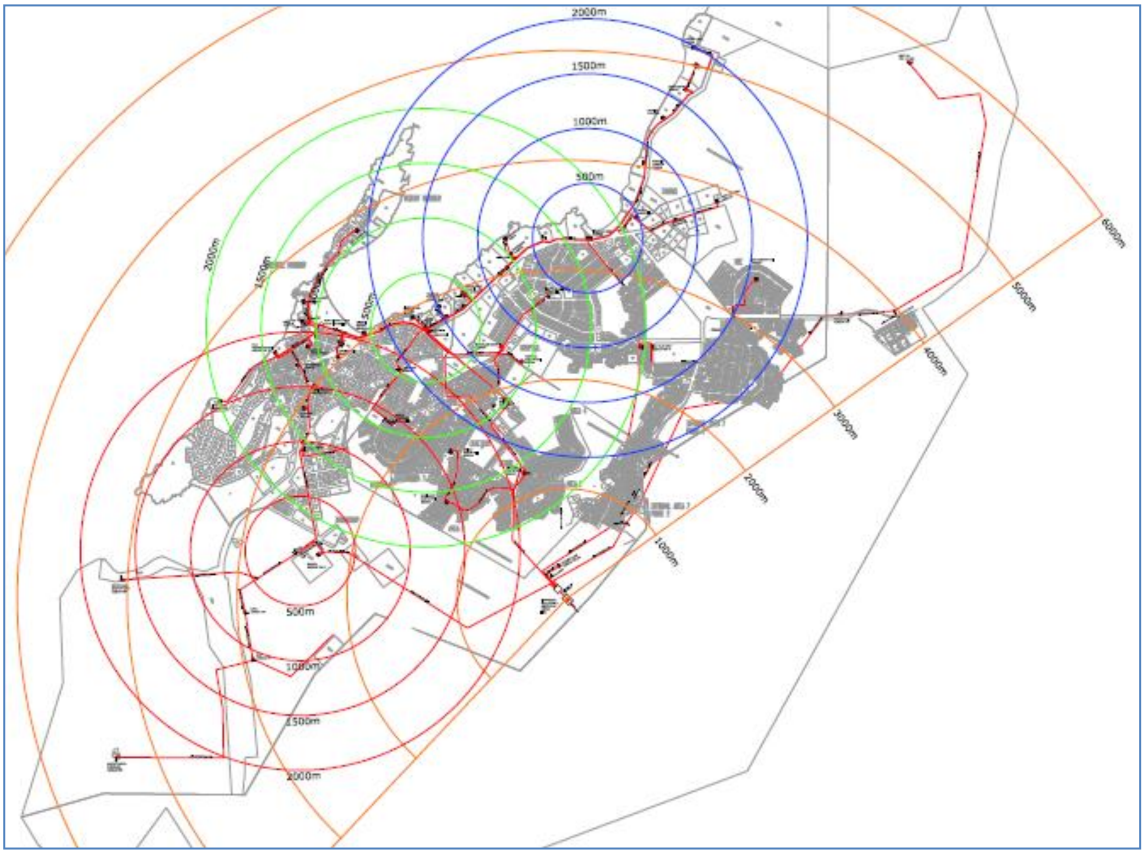
3.2.2 <u>Network EXTENSION Policy and Design criteria</u>

<u>Figure 4: Load transfer / Distance criteria.</u>



Load transfer / Distance criteria: Allow a maximum of 20 MVA for a 5-7km radius from a NamPower (132/66kV) in-feed point (at 11kV distribution level) [4]– this is assessed on critical loads at the far end, as well as system loading / fault levels.

Figure 5: Load transfer radii.



At this stage, the infeed points from NamPower of 10 MVA can cater for the requirement on hand. – Also, location and reach are within technical limits.

3.2.3 Redundancy (n-1) system

A system for which all relevant components are redundant units . A redundant unit is a component which outage will never lead to an interruption in the base state which cannot be restored by normal switching actions (i.e. normal network reconfiguration) alone. The base State is the state of the system where all components can operate as intended. *[Duplication of components: the installation of duplicate components or backup systems that are designed to come into use to keep equipment working if their counterparts (or several of them) fail]*

3.2.4 (n-k) system (n-2) system requirement for CRITICAL LOADS

A system whereby an outage of any k or less components will never lead to an interruption which cannot be restored by normal switching actions (i.e normal network reconfiguration) alone. The CBD area as well as Industrial area could be considered as a critical load, and the medium term could provide for a 3rd feeder to the industrial site.

3.2.4.1 Distribution

- Critical site: NamPower / ACC / Nautilus / CBD / Municipal load center – (n-2) application

[4] LTC 2010 reference

- Required: additional 1-2 (direct/indirect) feeders from NamPower Intake station via ACC and Nautilus, with the required capacity to supply the critical loads.
- Other nodes should all be on n-0 to n-1 redundancy –

3.2.5 System Reliability Assessment Functions

In general, the assessment of reliability indices for a power system network, or of parts of a network, is the assessment of the ability of that network to provide the connected customers with electric energy of sufficient quality.

3.2.5.1 Three different reliability assessment functions are considered:

- Contingency analysis:
  The non-stochastic assessment of maximum/minimum loadings and voltages for specific combinations of component outages
- Voltage sag assessment:
  The assessment of the frequency of occurrence of voltage sags.
- Network reliability assessment:
  The assessment of statistical interruption data for individual loads and busbars in the network.

Each of these calculation methods has its own typical applications. **Contingency analysis** can be used to determine power transfer margins or for detecting risky loading conditions. **Network reliability** assessment can be used to calculate expected interruption frequencies and annual interruptions costs, or to compare alternative network designs. **Voltage sag** assessment can be used to determine the expected number of equipment trips due to deep sags. (This is analyzed in the QoS (Quality of Supply) section.)

Based on predicted load-growth scenarios, as well as the proposed implementation of the n-1 system, the system reliability is considered to improve. A source of concern of course would be the old infrastructure in its current state, prior to the implementation of the network re-enforcement plan. When the network re-enforcement plan is implemented, the normal day to day work rehabilitating the existing infrastructure according to a plan must be maintained.

3.2.5.2 Notes

A reliability assessment project has the following phases.

- Specification of targets. The selected targets will determine which kind of calculation has to be made.
- Data collection. In addition to the electrical data, a stochastic reliability analysis asks for failure data, power restoration schemes, maintenance schedules, load forecasts, interruption costs, etc. It is important not to start by searching for the most accurate data that one could find, but to start a preliminary calculation with some best-guess data.
- Performing preliminary calculations, adjusting the analysis, checking input data. Interpreting results and changes in results. This phase is mainly to let you gather experience, and to find out how the results are being influenced by the input data.
- Data collection. In this phase, the search is for the best data that is available. The results of the previous phase are determining which data is important and which is not.
- Performing analysis and reporting.

The first decision to make is about the kind of reliability assessment that is to be performed. If no stochastic failure data is available, or when an "n-1'' analysis has to be made, then a contingency analysis is required.

Stochastic network reliability assessment is required for assessing load-point reliability indices as well as overall network indices regarding network adequacy. Network reliability assessment is more demanding than contingency in terms of required input data as well as in terms of required computation time and the number of produced results.

3.2.5.3 Network Reliability Assessment

The minimal required data for network reliability assessment are.

- A valid electrical model of the electrical power system including all relevant primary equipment.
- Basic description of the protection schemes.
- Switching times for emergency network reconfigurations.

Additionally, the following data can be used.

- Maintenance schedules for all relevant equipment.
- Load forecasts.
- Interruption costs functions ("customer damage functions'').
- Load priorities, transfer percentages and shedding steps.

After the electrical model of the electrical system has been tested by load-flow calculations or - preferably - by running a "n-1'' contingency analysis, the preparations for stochastic reliability assessment can start with the entering of failure data for lines and cables.

4 Load forecasting, Network Analysis, Development Scenarios, Design Options

The **Electrical Master Plan** for Lüderitz involves the Electrical Network Analysis, technically and financially. This chapter will focus amongst others on load forecasting, load zones as well as asset-based information.

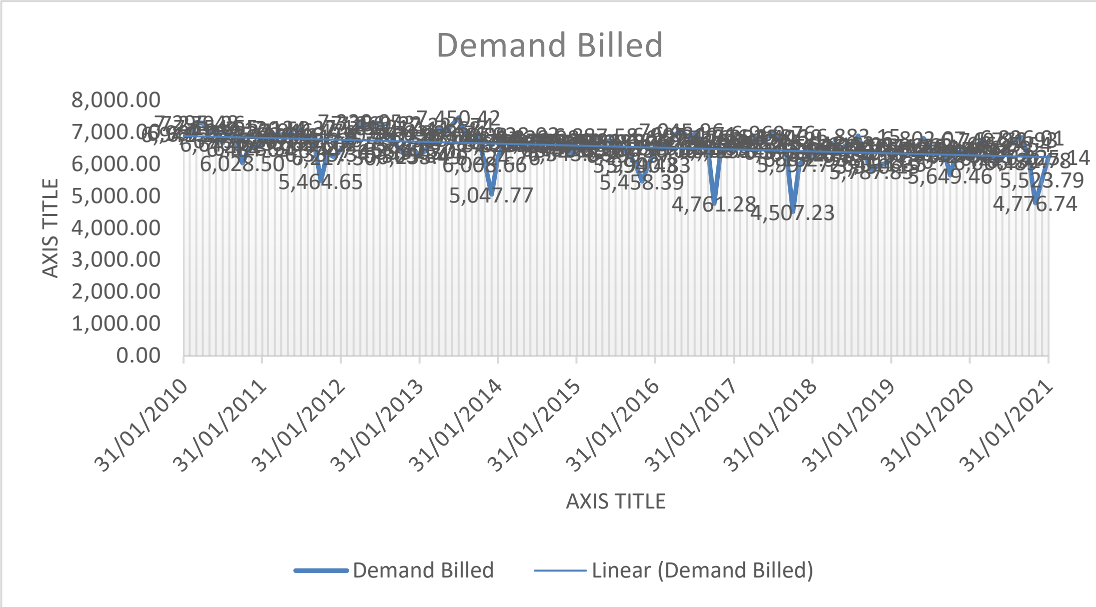
4.1 Load Profiles and Load forecast

Load-growth and Load forecast – are based on different approaches, factual and statistical based, are applied to derive loads, load profiles, annual / seasonal variations. Key information on hand (historical and present) is utilized to determine the profiles (e.g. used for tariffs and DSM (Demand Site Management) issues).

Load Profiles are typical for a town with business, commerce, and residential components – whilst industry will be absent other than light industrial activities.

In 2005 the load peaked at almost 9 MVA. Ever since a steady decrease to currently approx. 7MVA is reflected. Due to increased efficiencies and decreased activity in the fishing industry, a steady decrease has been observed in the demand and energy consumption. The trend is aggravated by increased PV penetration, resulting in a worse net load factor.

Figure 6: Monthly Demand Profile – 2025 - 2021



Enclosed historic trend -2000-2025. [5]

4.1.1 Expansion

Based on data and planned current developments

- Namport Expansion
- Fishing Industry (Pescanova) / Whitefish industries / Abalone (marginal) / Residential Developments. - (refer Structure plan)
- Tourism (Waterfront extensions)
- Energy Development Drivers
- H2 project support.
- Oil-Gas service industry.
- Area Densification Projects.
- Fishing Industry.

The economic growth in the Karas region (mining), housing developments, Green Hydrogen / other plant etc. – a substantial growth is envisaged in the short to medium term. It is anticipated that the downward trend can be absorbed to a steady or increased demand. The energy consumption will however decrease (due to the MSBM policy and PV NET metering rules. The risk on revenue must be mitigated by good reflective and fair tariffs.

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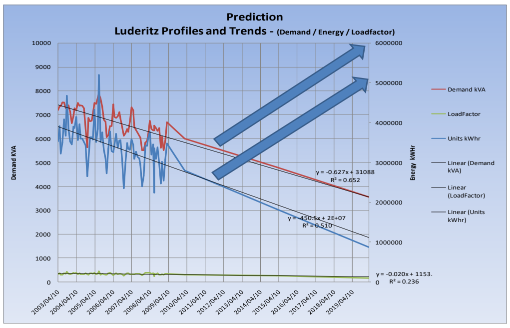
[5] FOOTNOTE – trend



Based on average data, it can be assumed at **0 -1.5%** for both energy and demand may optimistically be forecasted. With step-loads once the FID (Financial Investment Decision) for Oil, Gas, H2 related projects have been finalized, the increased load can grow to 5% per annum.

Developments, as outlined below, if accelerated due to capital inflow and development / grant funding of projects, will accelerate the growth, and might have an exponential figure.

In this scenario the current 10MVA supply from NamPower might not be adequate for the next 10-year horizon. It is currently predicted (based on economic indicators) that the load will surpass the available capacity of 10MVA in or before 2030, based on current growth and developments.

Table 1: Growth/development Parameters –

	Energy	***Demand***	***Load-factor***
Percentage growth p/a as per trend	-3.1%	-2.7%	56%
Percentage growth p/a as predicted	**2.4%**	**2.4%**	**56%**

Table 2: Growth/development load prediction

Zones	**present**	**Yr5**	**Yr10**
Year	2025	2030	2035
Predicted [MVA]	7.15	*???* *8 MVA*	*???* *10MVA*

4.1.2 Spatial development approach

A separate approach is followed assigning load densities to areas, as well as load nodes. Load densities are associated with the land utilization, i.e. commercial, industrial, business, residential, institutional etc. – the spatial approach, it is assumed that load densities as assigned in KVA/area derive an accurate forecast for the ultimate load – this is realistic and compares to the actual forecast as per

Based on known variables, the loads are determined and a forecast derived –

Figure 7 :Land use land nodes –

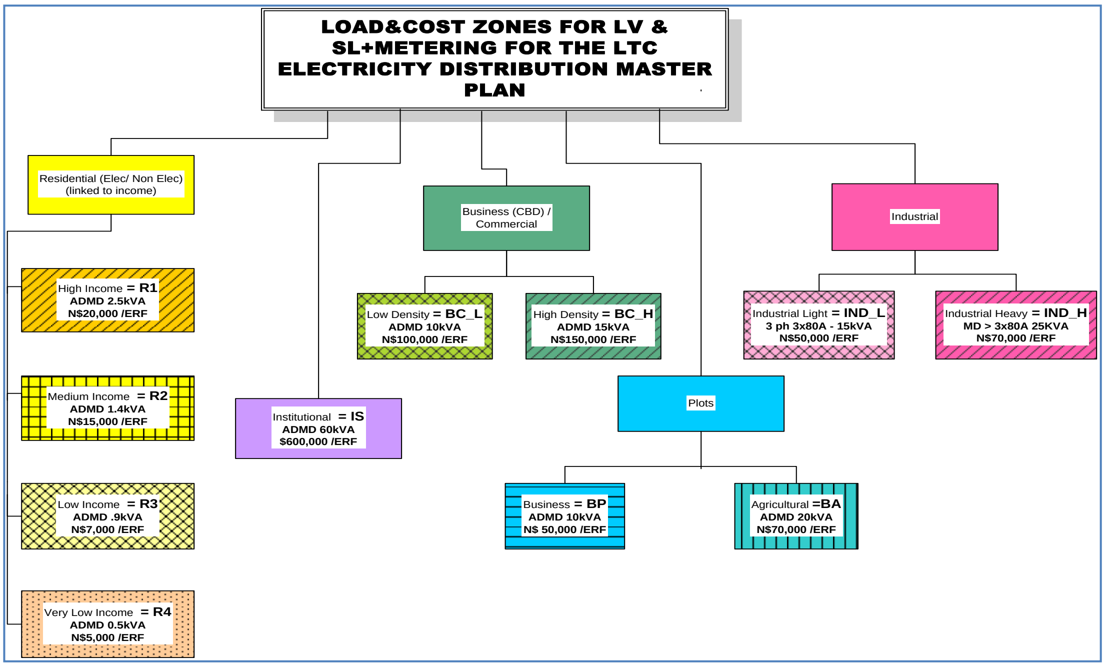
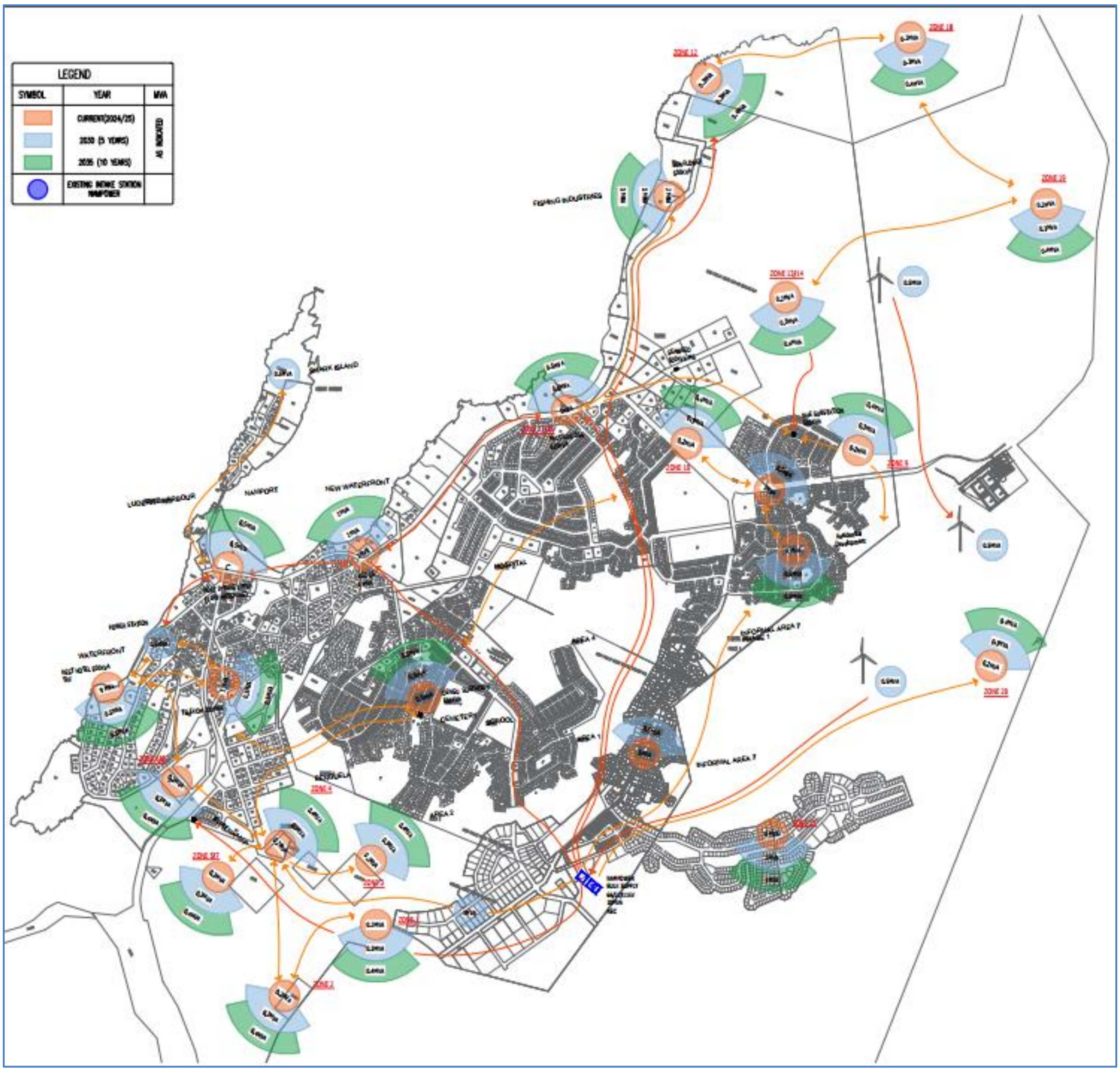


Figure 8 : Load Node Demand Forecast (current, 5 years, 10 years)

LEGEND		
SYMBOL	YEAR	MVA
(orange)	CURRENT(2024/25)	AS INDICATED
(light blue)	2030 (5 YEARS)	
(green)	2035 (10 YEARS)	
(blue circle)	EXISTING INTAKE STATION NAMPOWER	



Evaluated load nodes (based on area density) have been populated on the Lüderitz town electrical map, and major power flows (present [red], 5 years [orange], green [10years]) are listed. These are considered pivotal in the later load-flow study, assessing the required network upgrade, and associated timing thereof.

Table 3 : Spatial Load Forecast

Zones	present	Yr5	Yr10
Year	2020	2025	2030
Informal area - Area 7	1	0.5	0
Residential Development	1	0.5	0.5
Graveyard / NHE	1	0.5	0
Nautilus	1	0.5	0.5
Fishing Industries	2	1	1
ACC (processing)	1	1	1
New Waterfront	1	1	1
NamPort	1	0.5	0.5
Shark Island	0.5	0	0
PowerStation	0.5	0	0
NestHotel Waterfront	1	0.5	0.5
CBD - Telecom	1	0.5	0.5
Dengu Area	1	0.5	0.5
Residential Area 9	0	1	0
Future unforeseen	0	2.5	2.5
	13	10.5	8.5
		23.5	
			32
Factor ___ diversity	6.5	11.75	16
0.5	MVA	MVA	MVA
Measured MD (2021)	7.1		

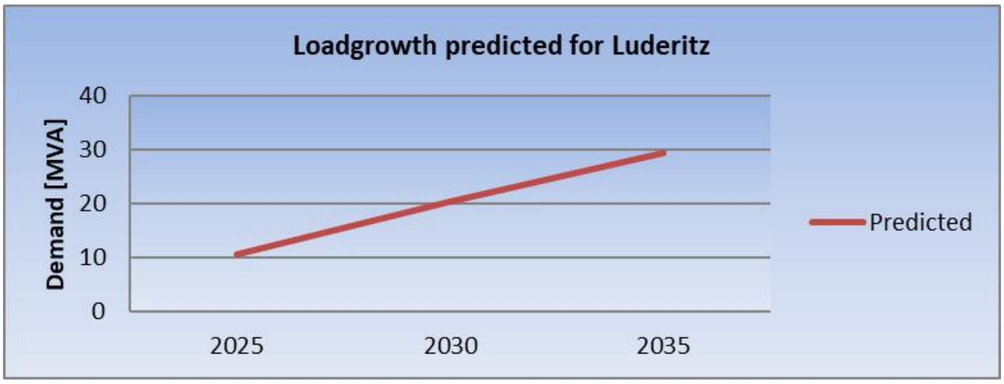
Zones	present	Yr5	Yr10
Year	2025	2030	2035
Informal area - Area 7 ZONE 17	1	0.5	0
Residential Development	1	0.5	0.5
Graveyard / NHE	1	0.5	0
Nautilus	1	0.5	0.5
Fishing Industries	2	1	1
ACC (processing)	1	1	1
New Waterfront	1	1	1
NamPort	1	0.5	0.5
Shark Island	0.5	0	0
PowerStation	0.5	0	0
NestHotel Waterfront	1	0.5	0.5
CBD - Telecom	1	0.5	0.5
Dengu Area	1	0.5	0.5
Residential Area 9	0	1	0
NEST HOTEL	0	2.5	2.5
Zone 4 - Benguela Industry	0.2	0.3	0.4
Zone 5 - Benguela Industry	0.2	0.3	0.4
Zone 6- NEST HOTEL /Industry	0.2	0.3	0.4
Zone 7	0.2	0.3	0.4
Zone 8	0.2	0.3	0.4
Zone 9	0.2	0.3	0.4
Zone 10	0.2	0.3	0.4
Zone 1 Benguela / Area 2	0.2	0.3	0.4
Zone 3 Benguela / Area 2	0.2	0.3	0.4
Zone 13-14	0.2	0.3	0.4
Zone 19	0.2	0.3	0.4
	15.2	13.8	12.9
		29	
			41.9
Factor ___ diversity	10.64	20.3	29.33
0.7	MVA	MVA	MVA
Measured MD (2021)	7.1		

Figure 9: 2022/23// 2024/25 revised outlook.

Note- any future offset on the RE plan – i.e. Wind Contribution is not considered to offset NamPower Import. The revised forecast is based on the new spatial development structure plan as presented by SPC in 2024.

4.1.3 Load forecast- planning

Zones	present	Yr5	Yr10
Year	2025	2030	2035
Predicted	10.64	20.3	29.33



4.2 Network analysis (Simulations) - Load-flow study

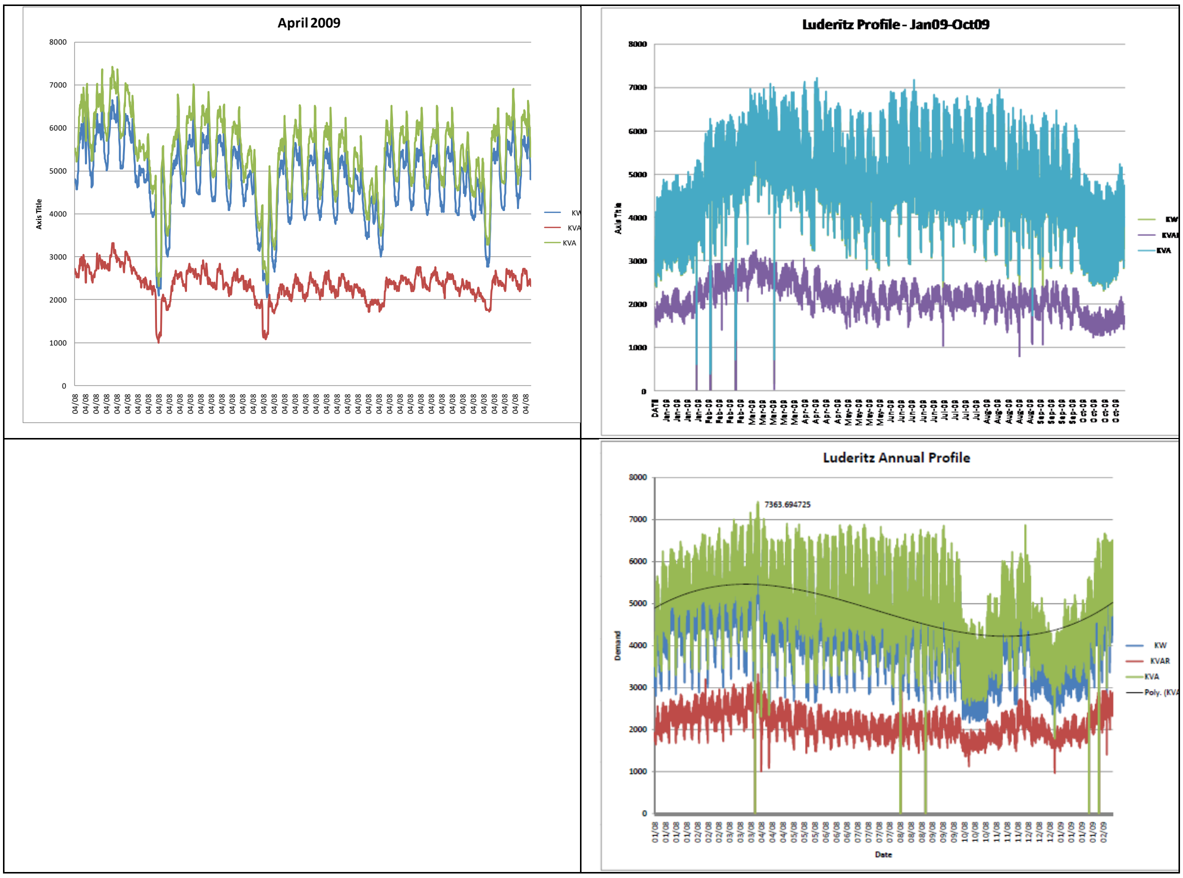
Based on the measured peak-demand, as well as linked to the data-recording of separate feeders on the town, a full and comprehensive load-flow study was completed.

The DiGSILENT ® software was utilized for the simulation. Based on the specific feeders as well as the overall load, **peak demand of recently 7.3 MVA** was used to simulate the loads on the network.

As preparation for the initial survey, load recordings were done on all main town feeders. For Lüderitz these are essentially the two parallel feeders from NamPower to the Lüderitz Intake switching station.

4.2.1 Load profiles (Daily/ Weekly)

Figure 10 : Town Load and Demand Profiles -



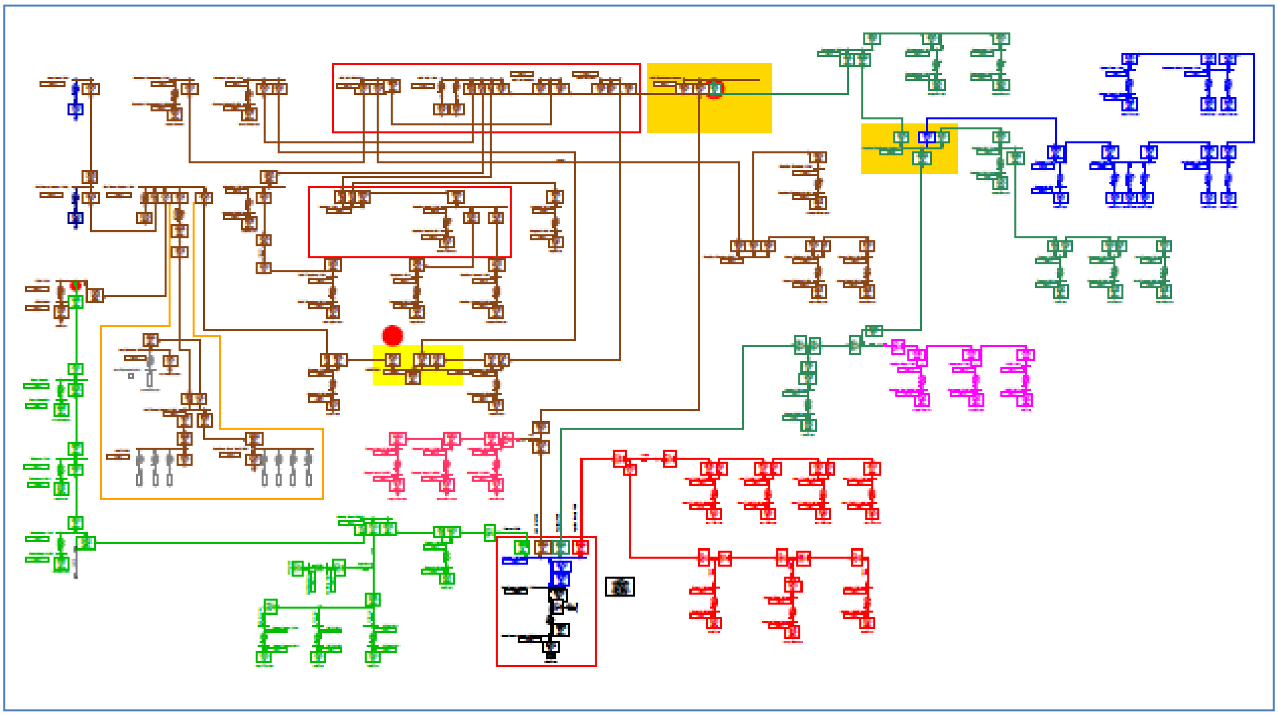
Time sweeps (i.e. load-flows as function of the daytime / season) are not considered. – No significant season variations are observed. Worst case scenarios are simulated, to ensure the system can perform under worst case scenarios.

5 Load-Flow Studies –

The load flow simulation software is a dynamic tool – and infinitely many cases could be simulated. –

The 'normal or best' switching scenario was simulated (based on feeder definitions), derivatives thereof analyzed. For a practical approach, the current shortcomings and critical paths were identified by the simulations, -

Figure 11 : Load flow network – 2025 (present)



5.1 Load analysis –

The predicted load in the different areas is used in the DiGSILENT © load flow simulation and network upgrade path consideration.

1. Short term analysis - present situation analyzed.
2. Predicted growth.
3. Natural growth and development
4. Growth and development with accelerated industrial input
5. Accelerated growth – scenario when grant funding would kick in the facilitate PSA (Progressive Settlement Areas) electrification and development as well as energy support services. -
6. The second part simulated the proposed long term (2022 …25) network with the associated load growth.
7.

Present Normal state				
Feeder	**Normal**		Luderitz existing Network with **Nautilus FDR out of service**	
	A	**MVA**	**A**	**MVA**
Prison	20	0.3806	20	0.3806
ACC	180	3.4254	371	7.06013
Nautilus	213	4.05339	0	0
AgathaBeach	34	0.64702	34	0.64702
Total load		8.50641		8.08775

5.2 Key results –

The existing network was modeled on DiGSILENT © and evaluated voltage profiles (and short circuit levels – which are critical for proper operation of the protection devices).

The first step was the current network (year 2025) based on the current peak load –

Certain simulations we conducted to test the redundancy of the system, i.e. simulations without some critical feeders. – Simulation exercise to analyze current performance of the system –

5.2.1 From the layout – key simulations based on nodes identified are addressed

- Network as is with current load distribution.
- Network as is WITHOUT the feeder to ACC.
- Network as is WITHOUT the feeder to Nautilus.

The network, cable loading and voltage profile are analyzed. – The results are commented subsequently.

Figure 12 : Lüderitz 11kV Network 2020

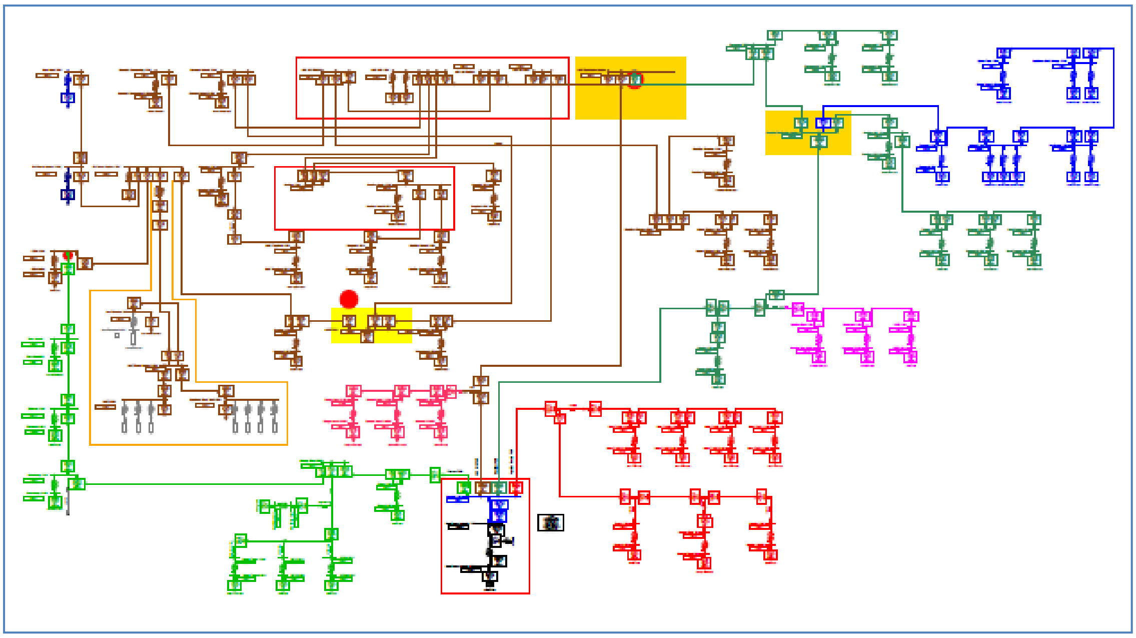
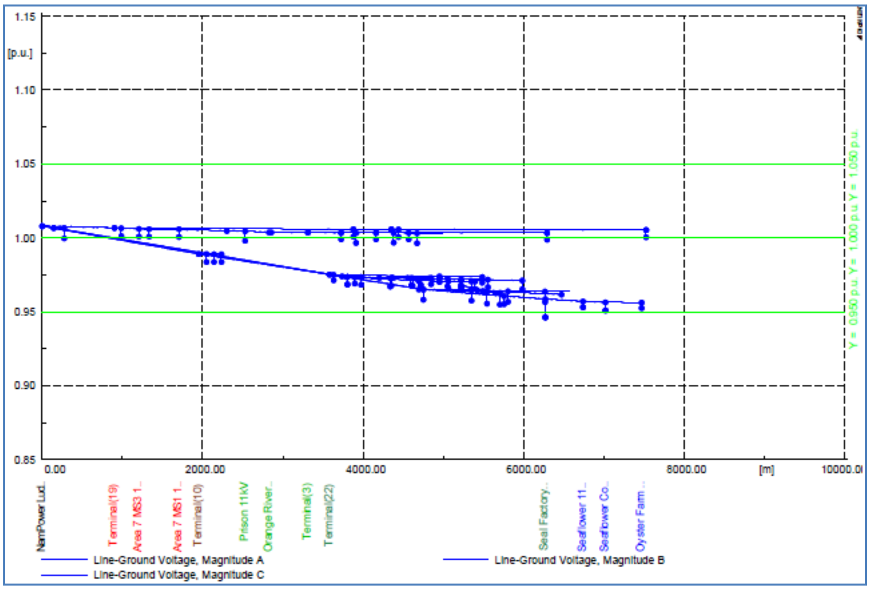


Figure 13 :Voltage Profile – 2020 (Lüderitz)



Comment: currently the voltage profile – with normal operating conditions, is adequate, but marginal on the industrial feeder extending via Nautilus to the industrial area.

Figure 14 : Lüderitz 11kV Network 2020 with ACC FDR Out of Service

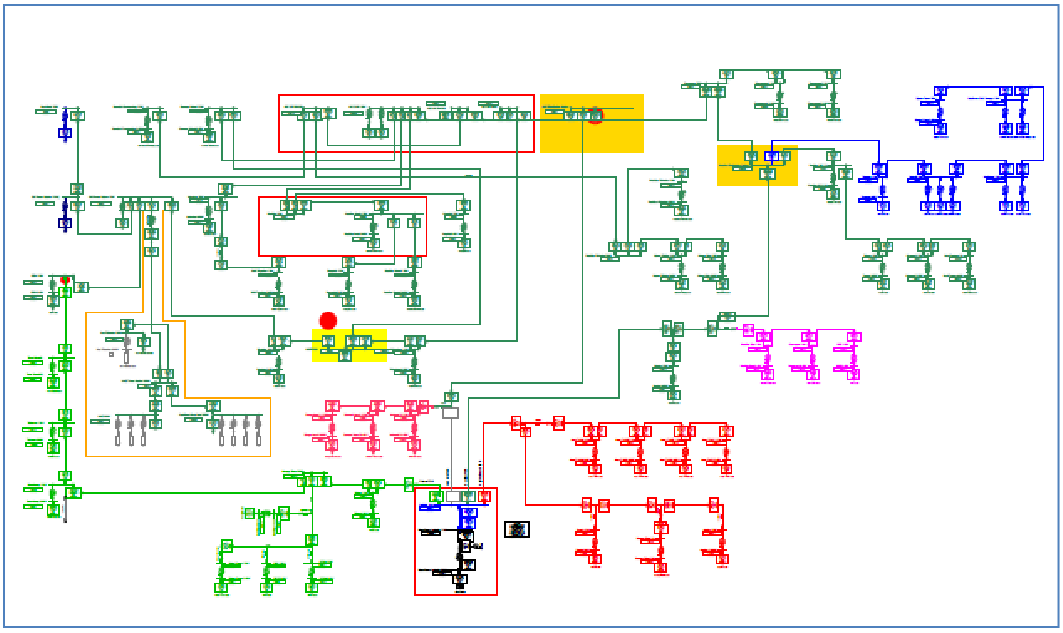
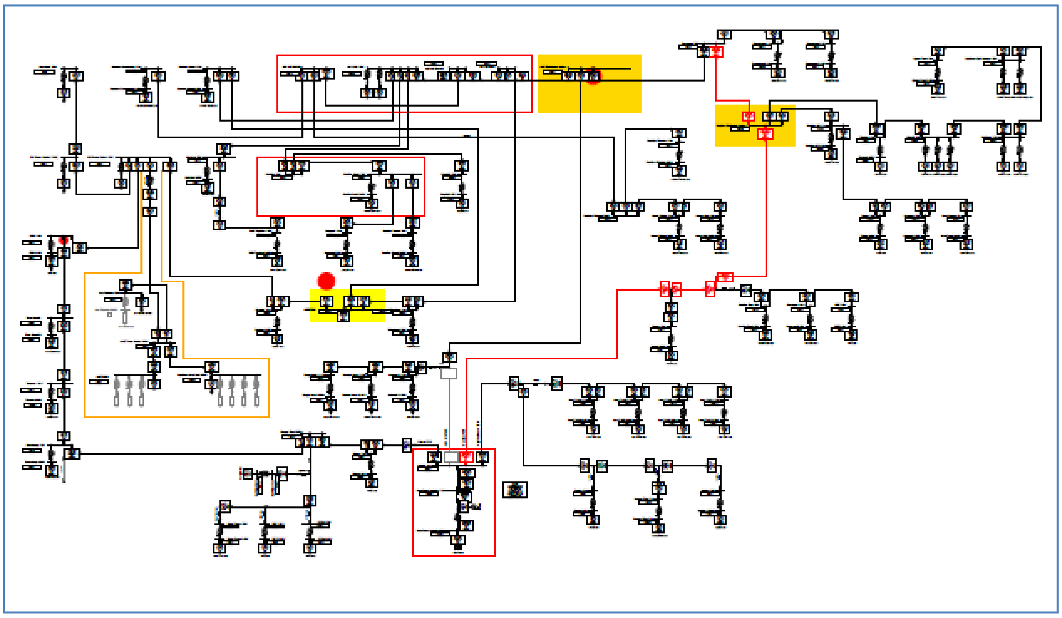


Figure 15: Lüderitz 11kV Network 2020 with ACC FDR Out of service cable overload.



Comment: With the ACC feeder out of service – the cable to Nautilus is overloaded.

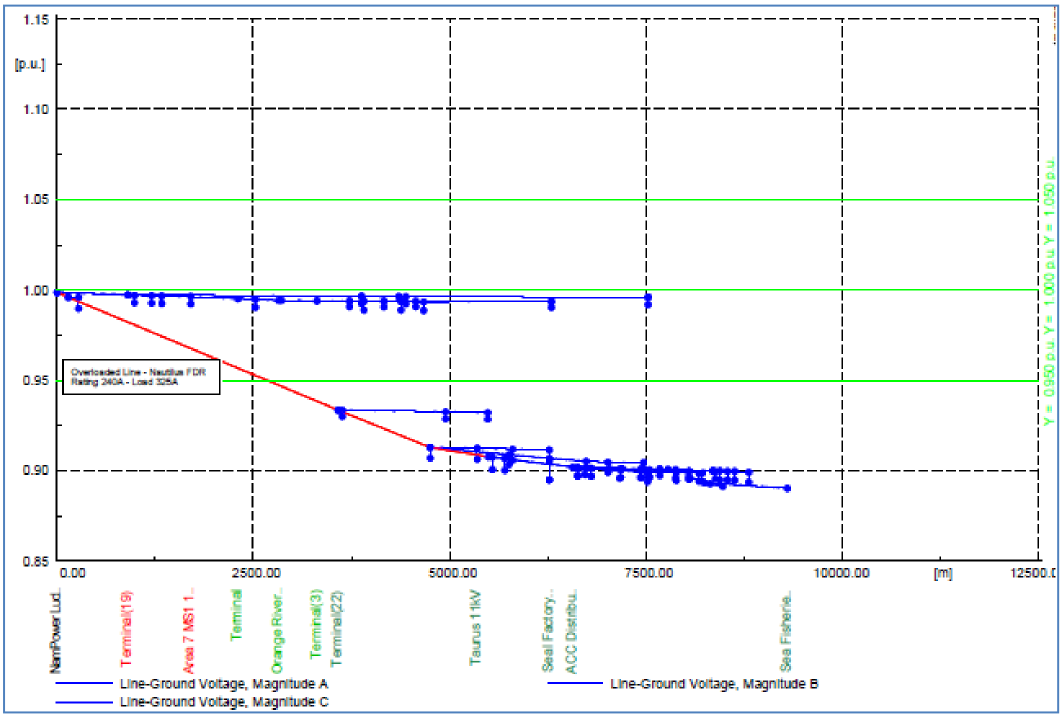


Figure 16 : Lüderitz 11kV Network 2025 with ACC FDR Out of service Voltage Profile

Comment: With the ACC feeder out of service – the voltage profile is outside the limits and cannot cater for the demand.

Figure 17 :Lüderitz 2020 with Nautilus FDR out of service.

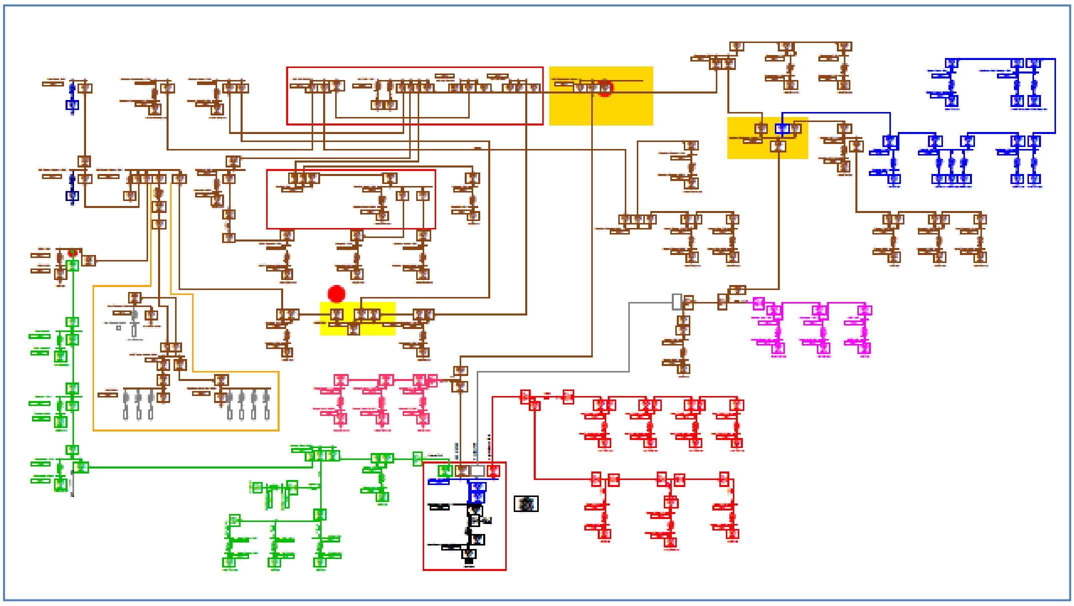
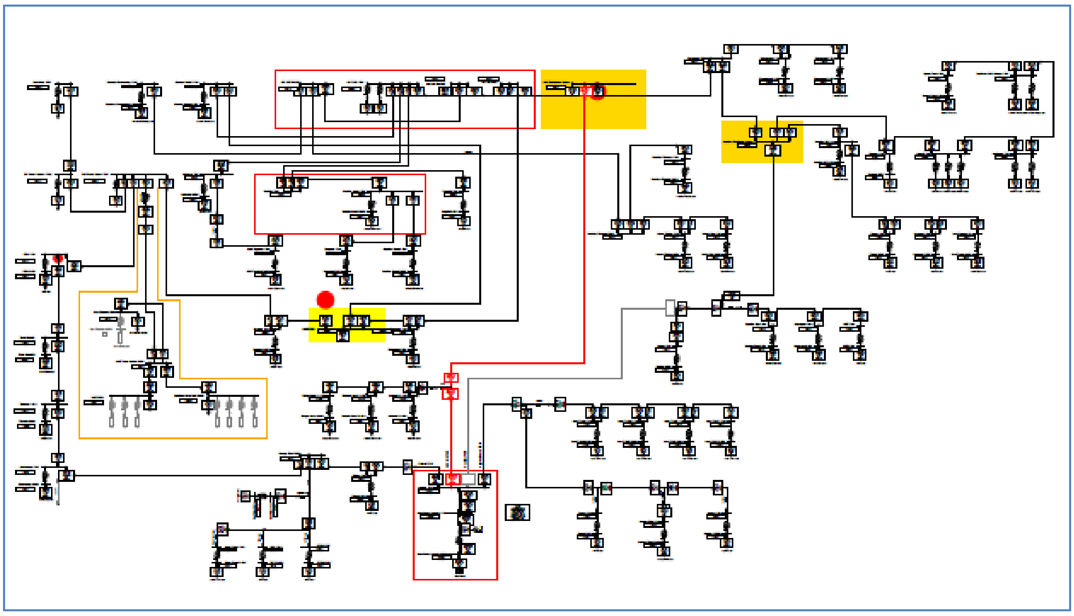
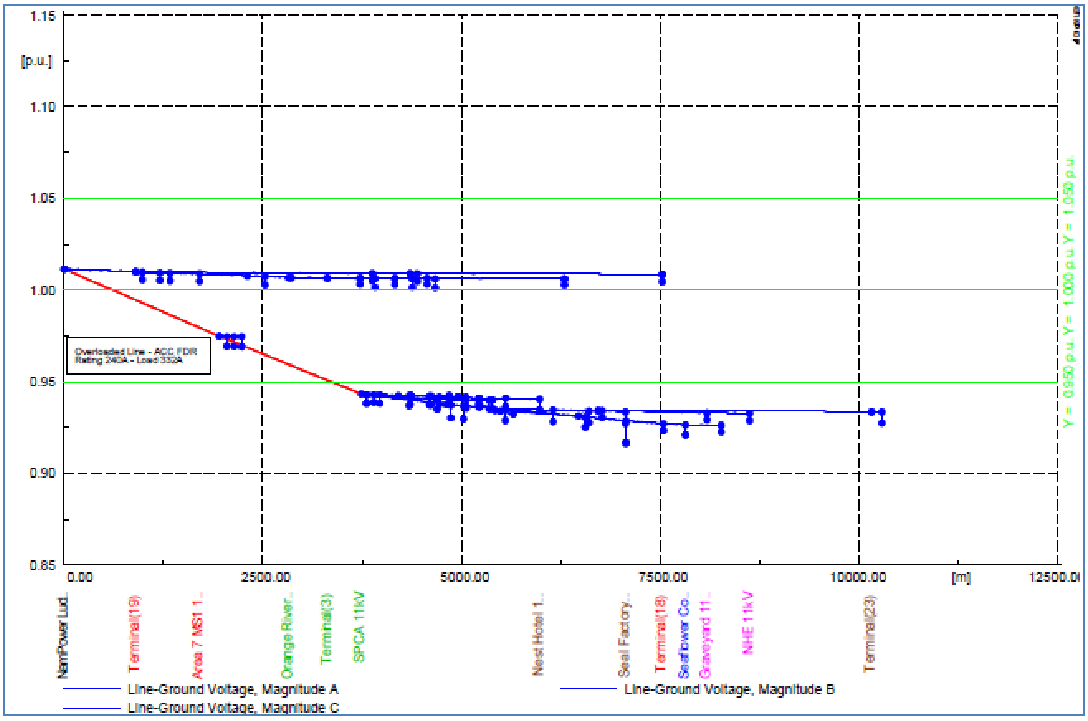


Figure 18 :Lüderitz 11kV Network 2020 with Nautilus FDR out of service - cable overload.



Comment: With the Nautilus feeder out of service – the cable to ACC is overloaded.

Figure 19 : Lüderitz 2020 with Nautilus out of service Voltage Profile



Comment: With the Nautilus feeder out of service – the voltage profile is outside the limits and cannot cater for the demand.

5.3 Upgrade paths (as outlined in the projects) – Primary tasks

Network re-enforcement is required. – key considerations are to improve the transfer capability – primarily – between NamPower Intake, Acc and Nautilus. Parallel cables / feeders are considered. –

A future LOAD CENTRE (Zone 5-8 / Burenkamp) is planned to create a southerly node, facilitating industrial development.

As indicated, underground cables (120mm2 Cu – 185m2 Cu XLPE cables are recommended) -

- NamPower Intake to ACC
- NamPower Intake to Nautilus (upgrade 2024 / line)
- ACC-ACC – STAND ALONE STATON
- NamPower – new LOAD CENTRE (- feeder cable / overhead line)
- (add 120 – 150 mm2 Cu XLPE cable in parallel) –

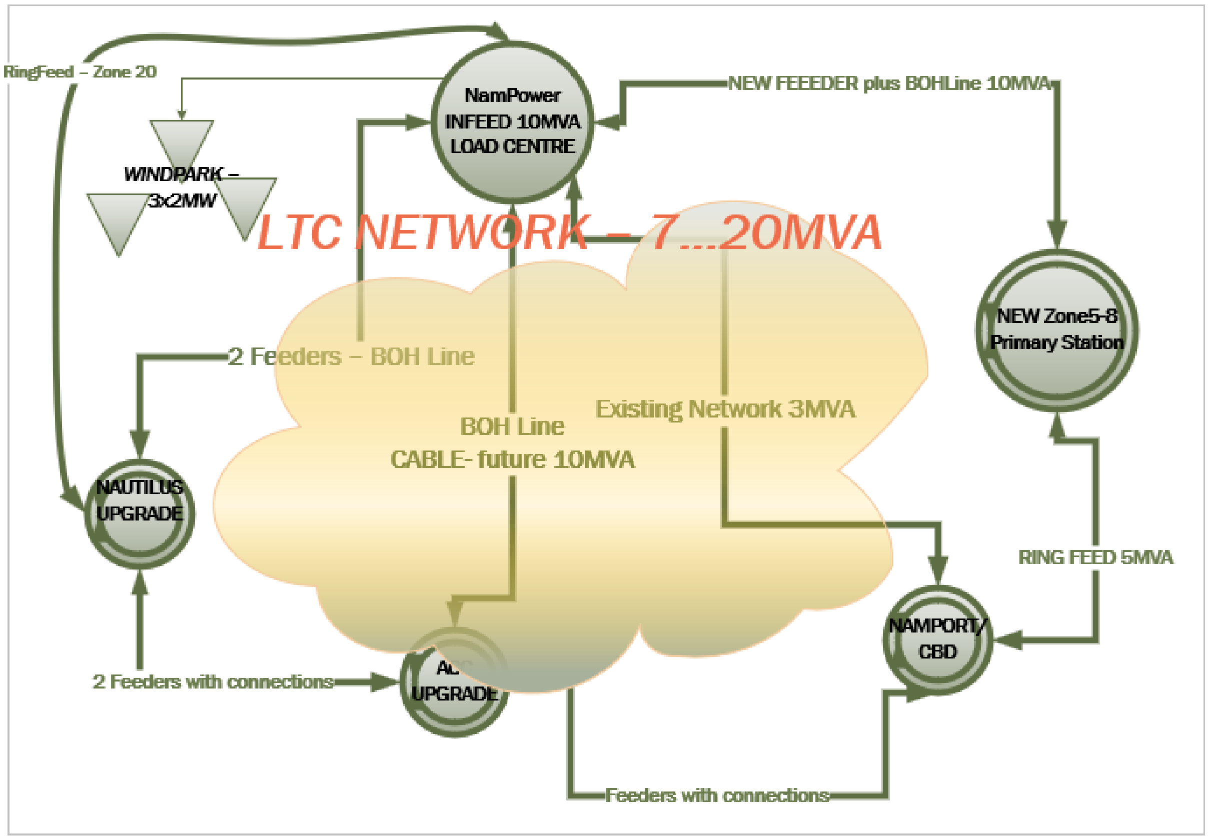


Figure 20: Planned LTC network – High Level load transfer – planning.

Due to financial constraints – copper 70mm2 or 90mm3 equivalent overhead lines are considered, as these are only <25% of the cost compared to cables. – A load/cost transfer assesses the scenario. 11kV overhead lines can be constructed, even as parallel conductors, to improve the current load transfer capabilities to ACC, Nautilus especially. – The feeder to the Agatha beach plant could also be an overhead line, to reduce the cost.

Figure 21 :Voltage profile 2025 – with normal growth anticipated, existing network.

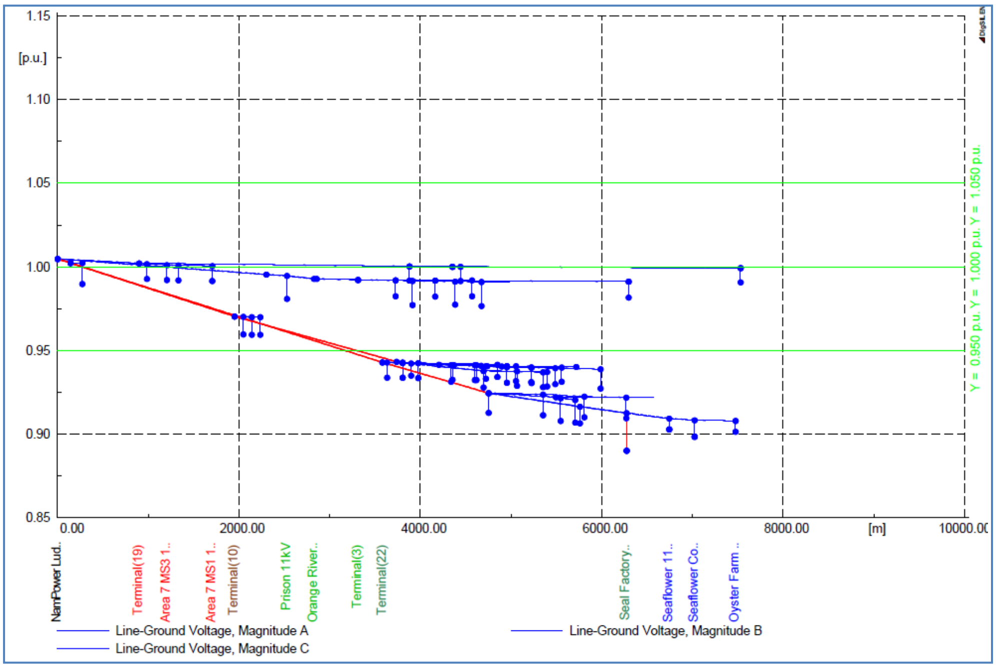
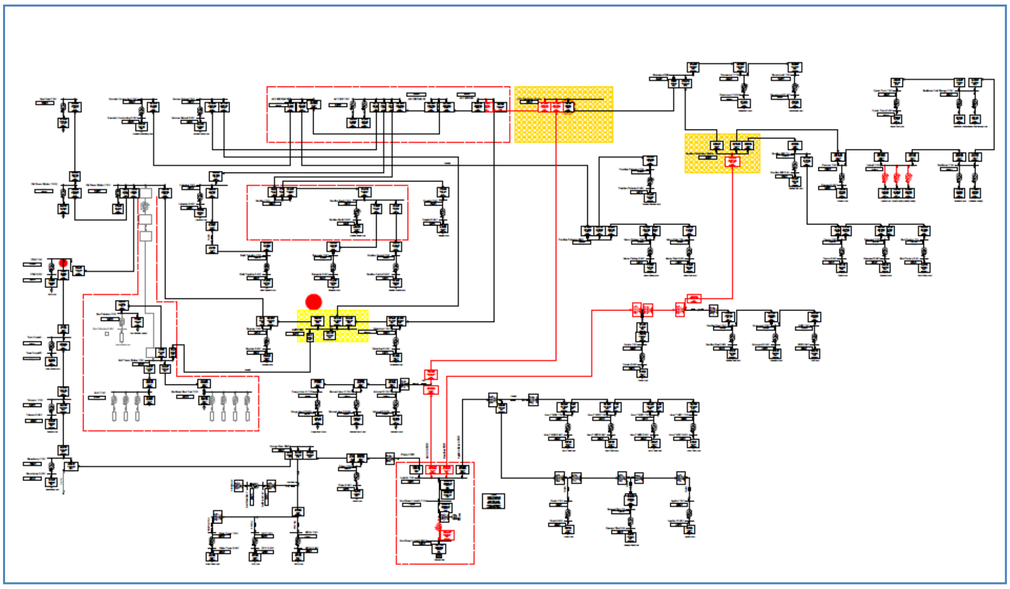


Figure 22 : Lüderitz Network 2025 showing overloaded cables.



5.3.1 Network re-enforcement plan – double circuits implemented

Figure 23 : Lüderitz Network 2025 with additional cables to ACC, Nautilus & ACC - ACC

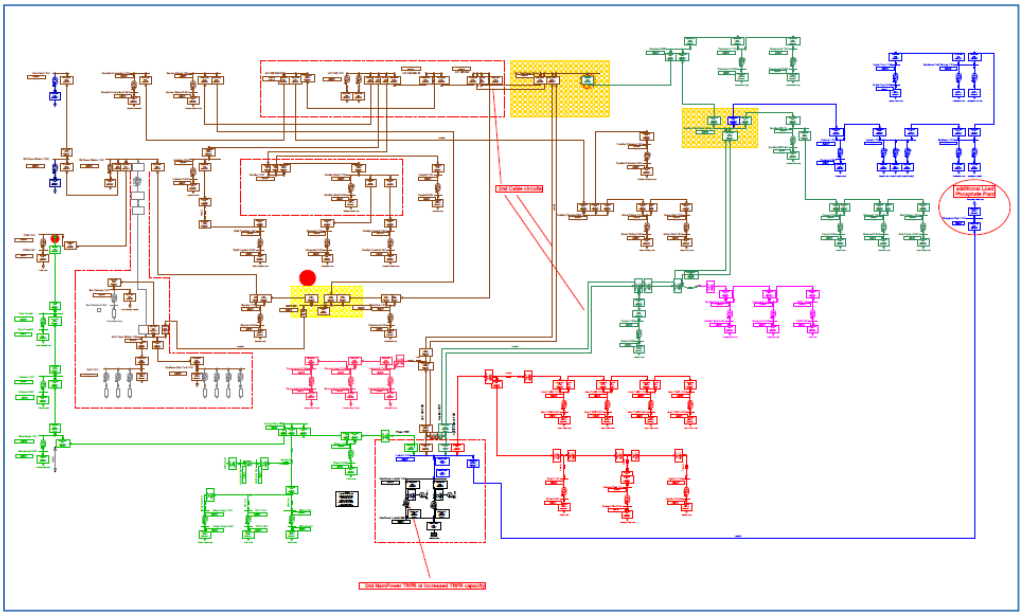
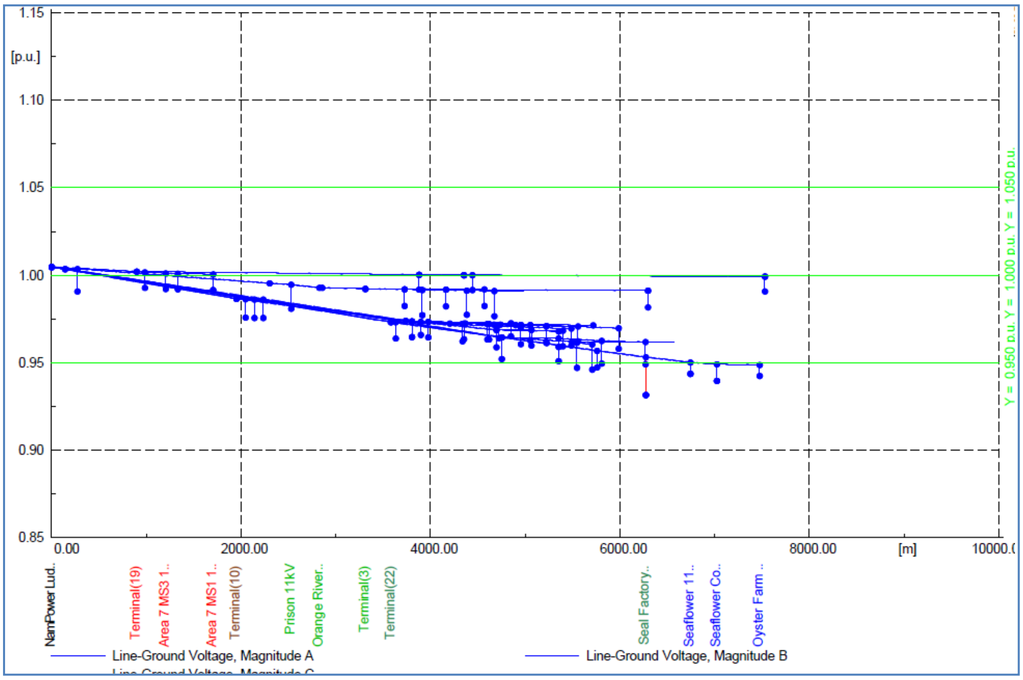
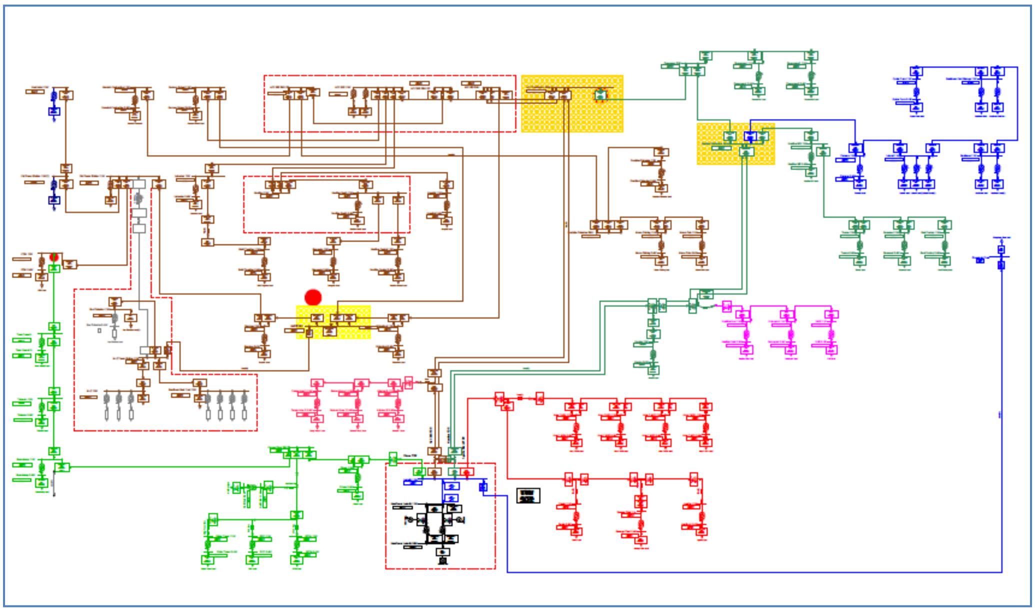


Figure 24 : Lüderitz Network 2025 with additional cables to ACC, Nautilus & ACC-ACC Voltage Profile



As evident – the system needs to be enhanced to cater for future growth – as well as redundancy. The 2020 network is included and presents a reliable network structure.

Figure 25 : Lüderitz Network 2030



5.4 Fault levels – (Incomer and S/S stations, line-end feeders)

Figure 26: 3Phase Fault all Nodes.

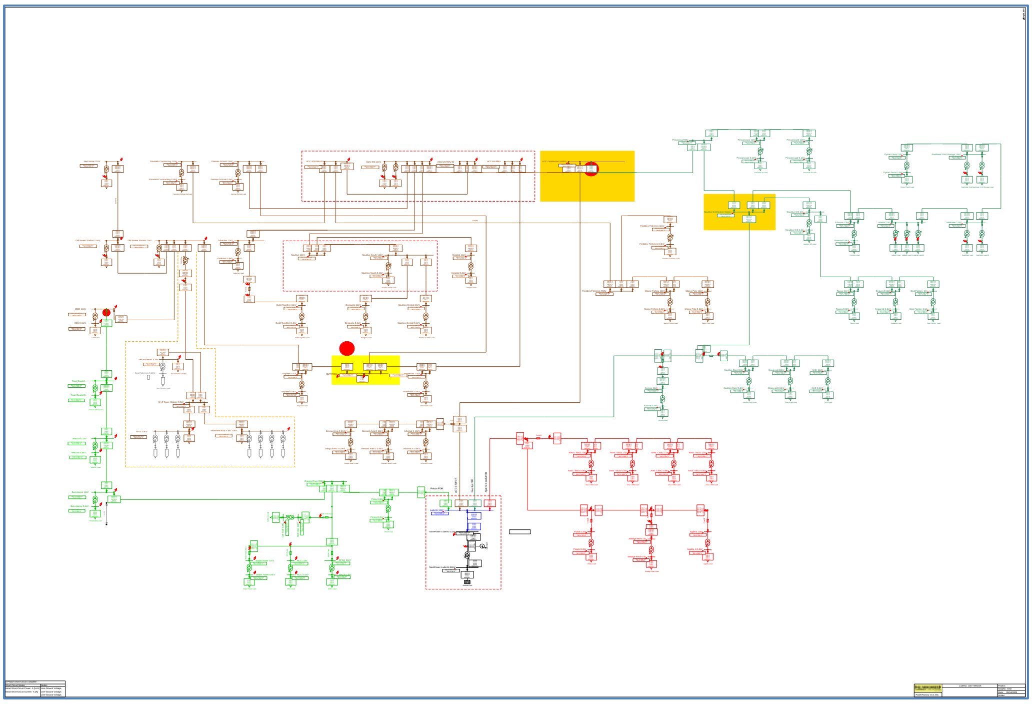
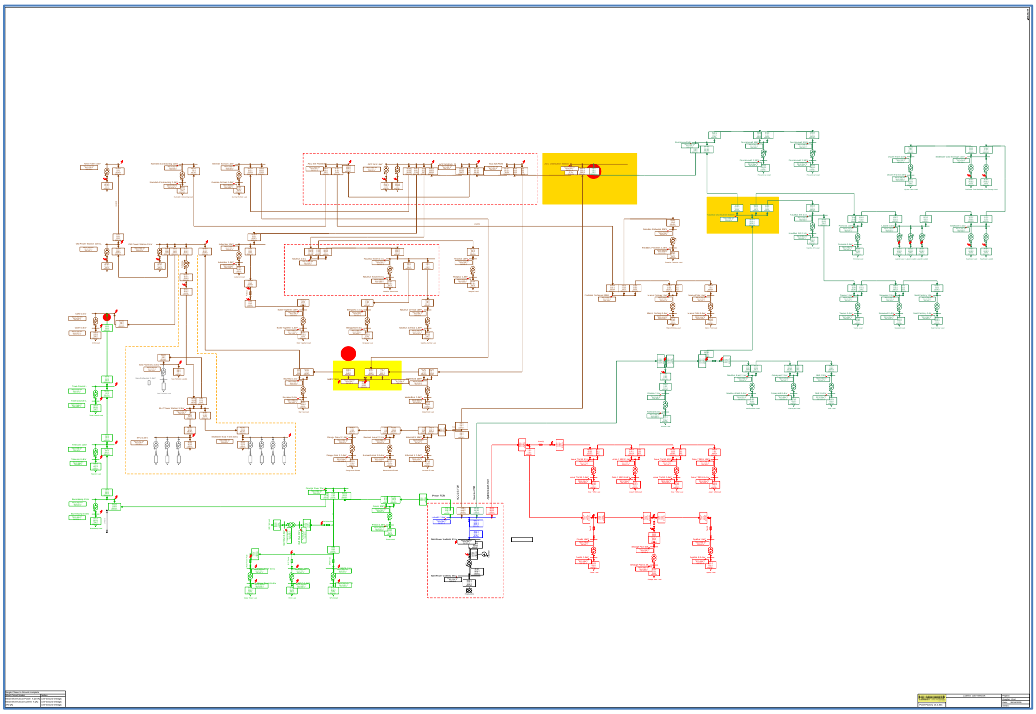


Figure 27: Phase-Ground Fault all Nodes.



Fault levels – for 3 phase and earth faults are simulated, which are essential for protection calculation – Adequate fault levels at the end (of rural feeders) are essential for the correct operation of the protection systems. – Hence on 11kV the long feeders should only be extended with rabbit conductors (lower impedance) and at a limited distance, having duly simulated all scenarios – this is applied to the Agatha beach extension. - Fault levels are adequate.

All tables / details are attached in the appendix. Load-Flow Simulation data –

5.4.1 Protection philosophy – fault levels

5.4.1.1 Protection co-ordination

A prerequisite for proper protection co-ordination is a comprehensive load-flow study. This implies that the network is modeled (as above, and respective fault currents are determined. –

The protection settings were set to allow the maximum current rating of each individual cable feeder -

- Fault levels consideration (especially for long lines)
- Protection Grading for O/C E/F
- Fuses (trip curves) co-ordination
- Load break Section links – o/lines.
- Fuses for transformer ratings, Slow blow / fast blow [K / T]

5.4.2 Protection philosophy:

Substation Transformer over-current Protection set to 100% of Transformer capacity at rated Voltage. When Load encroachment occurs i.e. overload / over current tripping, then the setting can be set to 120% of transformer capacity but steps need to be taken to increase TRFR capacity.

For feeders / cables, normally the rating of the feeder is considered for its over current Protection pick-up setting.

The metering system (if available) can also be programmed to “flag” a possible overload condition on Transformers or feeders.

The Protection for earth fault protection should be set sensitive enough to pick-up for the lowest earth fault in the respective network.

Any ring feed (if operated as such) should be equipped with unit protection or directional protection.

5.4.3 Settings / Programming of relays (based on simulations)

Last Stage Feeders can also be set to trip instantaneously if there is no other downstream Protection.

Devices, alternatively a setting to achieve a tripping time of 0.200 sec can be chosen.

Pickup currents are selected at cable rating.

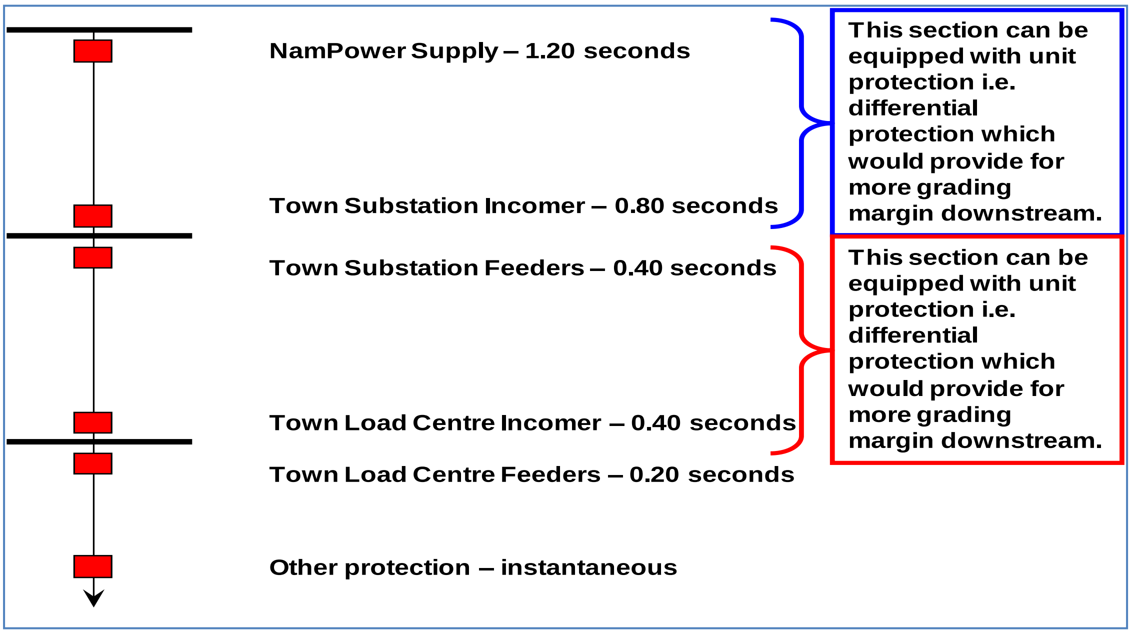
The time coordination between relays is small due to many protection devices in series, especially with the IDMT characteristic. A definite time characteristic (if available) could provide better coordination in addition to the IDMT characteristic.

The same philosophy can be used with all future Substations.

With the final commissioning of all protection in all Substations, CT Ratio selection & verification should be re-checked as well as the final relay settings for the specific types of relays.

All relay settings & relay setting coordination are worthless if the Substations Protection System is "solid" i.e. if the DC supply to the protection circuit is not operational.

Figure 28: Tripping times are coordinated as indicated in the attached figure.



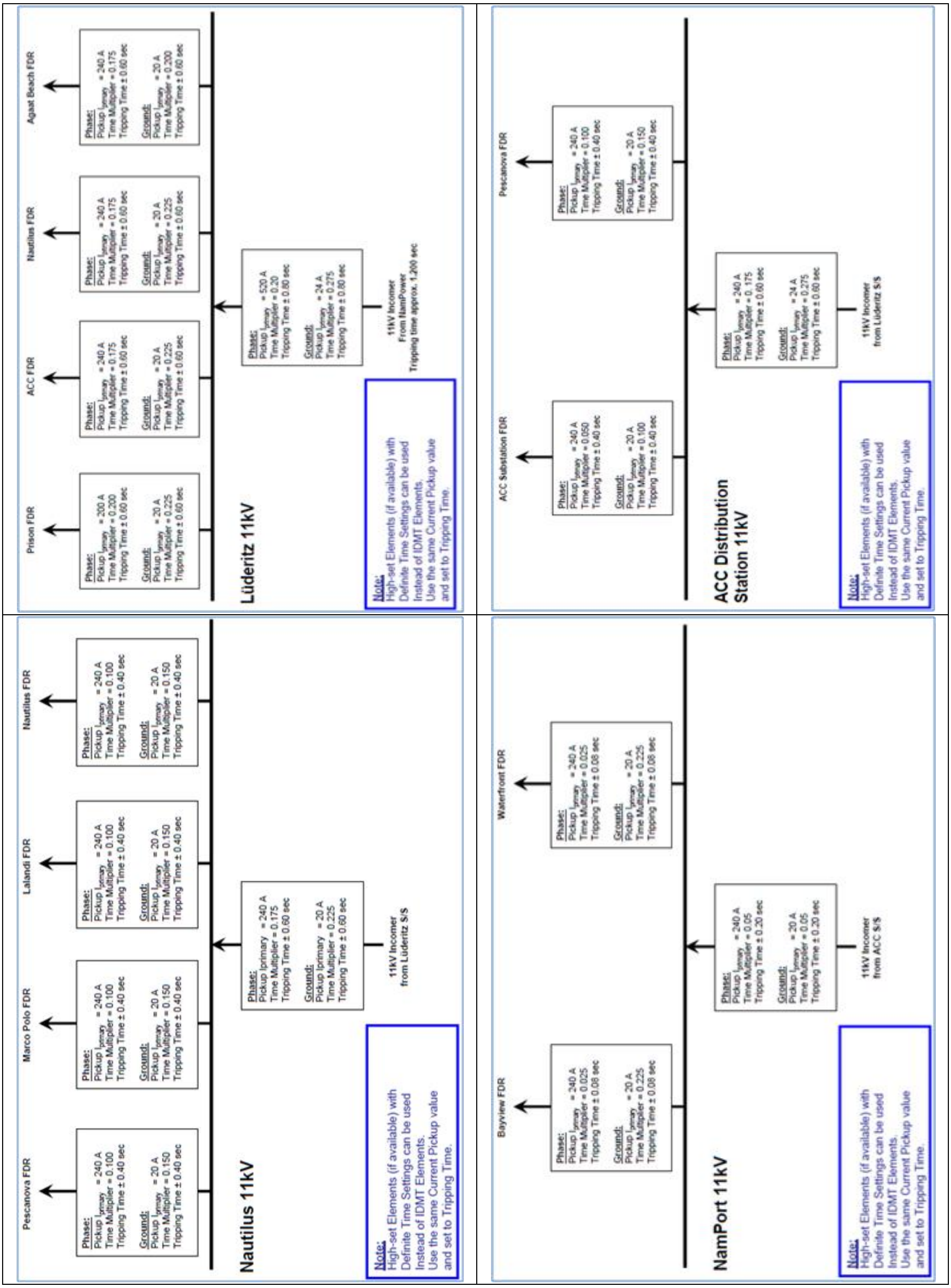
5.4.3.1 Protection philosophy (to be)implemented:

Relay pick-up currents were chosen as close as possible to the cable rating but also sensitive enough to pick-up for faults on the furthest part of the circuit.

The recloser tripping curves are selected to fast curves only, all faster than 0.1 second for a 3phase fault and about 0.04 second for a phase-to-ground fault on the system.

The reclosers are set to be set to lock-out with a fixed dead time of 4 seconds between the trips. Under certain circumstances this might cause upstream IDMT relays to advance during a fault and not reset totally between trips and cause incorrect trips of the IDMT relays.

5.4.4 LTC (Lüderitz Town Council) Relay / protection settings



5.4.5 Note: related to protection settings

•Last Stage Feeders can also be set to trip instantaneous if there are no other downstream Protection

Devices, alternatively a setting to achieve a tripping time of 0.200 sec can be chosen.

•Pickup currents are selected at cable rating.

•The time coordination between relays is small due to many protection devices in series, especially with the IDMT characteristic. A definite time characteristic (if available) could provide better coordination in addition to the IDMT characteristic.

•The same philosophy can be used with all future Substations.

•With the final commissioning of all protection in all Substations, CT Ratio selection & verification should be re-checked as well as the final relay settings for the specific types of relays.

•All relay settings & relay setting coordination are worthless if the Substations Protection System is “solid” i.e. if the DC supply to the protection circuit is not operational.

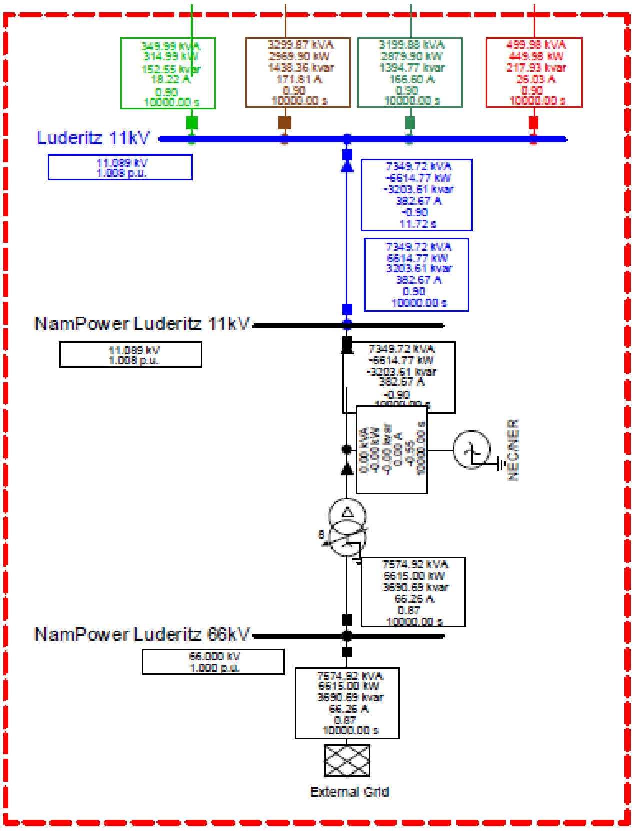
5.4.5.1 Transmission information - NamPower coordination

The main infeeds for the Karas Region are a 220kV and a 400kV interconnector from South Africa to Kokerboom Transmission Station (T/S).

The source will change with increased NamPower network strengthening.

Source impedance – Lüderitz is supplied from a 132/66/11kV transformer NamPower source. The fault levels are relatively high (i.e. a strong source), and hence fault levels in the town are high, and to be considered for fault calculations and substation design.

Figure 29 : Source impedance – Lüderitz.



Source: DZ file/DiGSILENT

5.5 Master plan - Development and Upgrade plans

Based on the load-flow simulations performed and anticipated load zones identified, short-, medium- and long-term strategies must be defined.

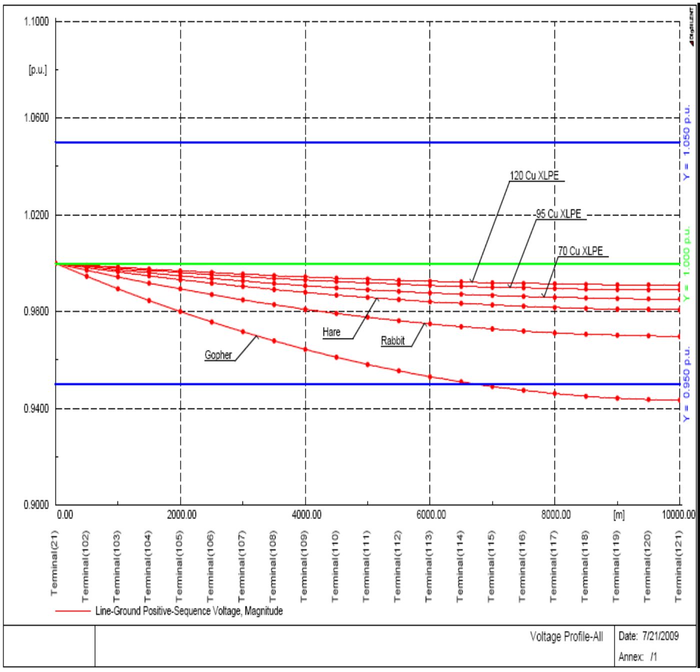
5.5.1 Technology options –

5.5.1.1 Feeders –

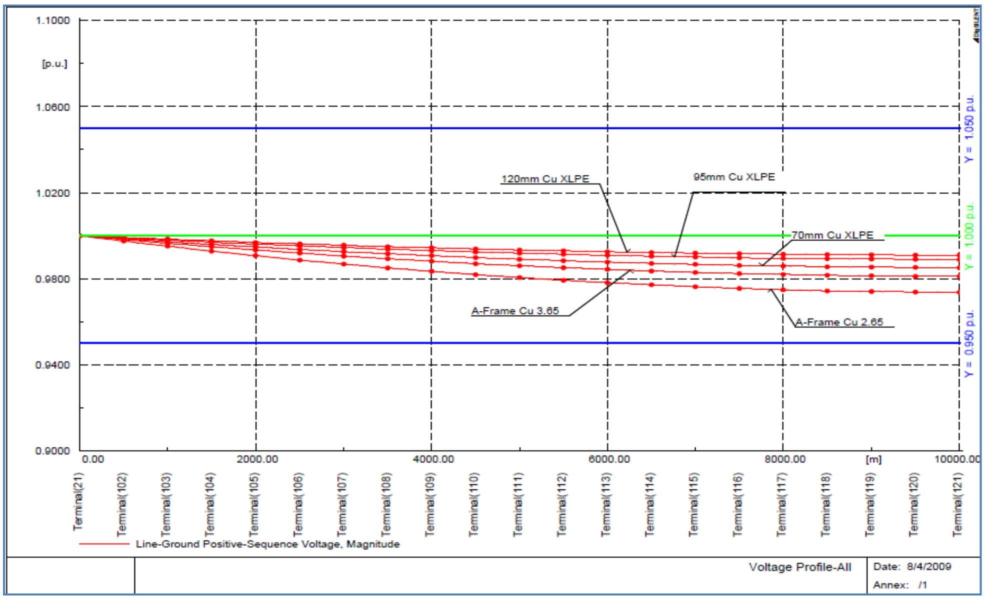
As per Lüderitz Town Council /BICON Engineers Inc. inception meetings, it was established that whilst underground distribution cables are the preferred option, overhead lines (for load transfer) are also acceptable as part of the Masterplan PIP (Project Implementation Plan) mainly due to cost considerations – Enclosed summaries and tables outline the scenarios –

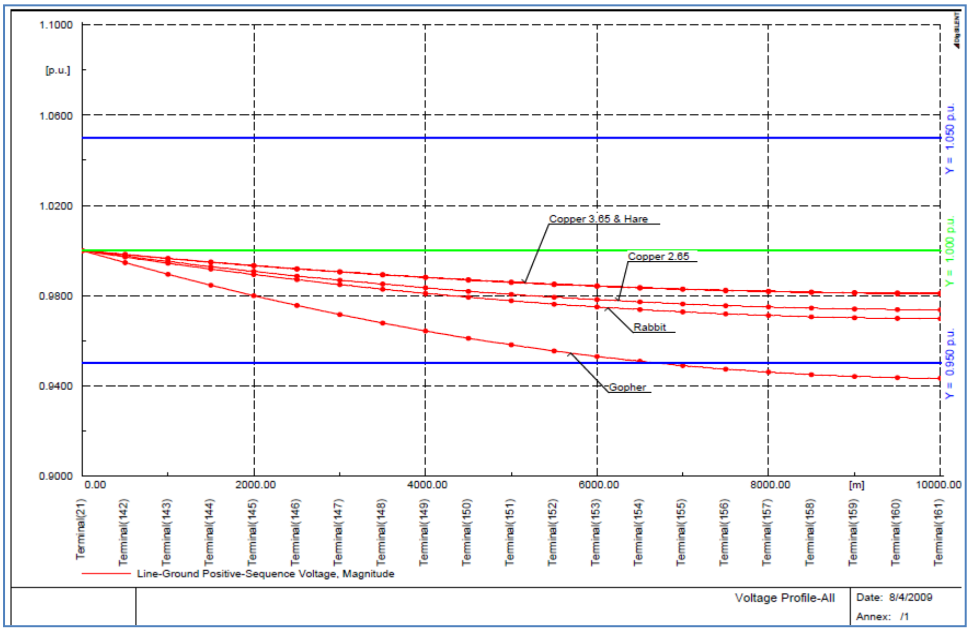
Figure 30 : Technology options – feeder comparison.

MV_Overhead lines	**CODE_Range**			cost/km	
Gopher: 11/22/33kV -	OH_G	150	A	N$	240,000.00
Rabbit: 11/22/33kV -	OH_R	240	A	N$	300,000.00
Hare: 11/22/33kV -	OH_H	360	A	N$	360,000.00
70Cu 7/3.35mm2 : 11/22/33kV -	OH_70Cu	360	A	N$	360,000.00
90 Cu 7/2.25mm2 : 11/22/33kV -	OH_90Cu	440	A	N$	540,000.00



Cost Estimates for Infrastructure Capital Projects									
MV_Overhead lines	**CODE_Range**			cost/km				total/m	
Gopher: 11/22/33kV -	OH_G	150	A	N$	320,000.00			N$	320.00
Rabbit: 11/22/33kV -	OH_R	240	A	N$	400,000.00			N$	400.00
Hare: 11/22/33kV -	OH_H	360	A	N$	480,000.00			N$	480.00
70Cu 7/3.35mm2 : 11/22/33kV -	OH_70Cu	360	A	N$	480,000.00			N$	480.00
90 Cu 7/2.25mm2 : 11/22/33kV -	OH_90Cu	440	A	N$	720,000.00			N$	720.00
MV_Cables (installed)				cost/m		cost/m		total/m	
70mm2 Cu XLPE TypeA	70XLPE	240	A	N$	1,400.00	N$	500.00	N$	1,900.00
95mm2 Cu XLPE TypeA	95XLPE	290	A	N$	1,760.00	N$	500.00	N$	2,260.00
120mm2 Cu XLPE TypeA	120XLPE	325	A	N$	2,000.00	N$	500.00	N$	2,500.00
150mm2 Cu XLPE TypeA	150XLPE	360	A	N$	2,200.00	N$	500.00	N$	2,700.00
185mm2 Cu XLPE TypeA	185XLPE	410	A	N$	2,640.00	N$	500.00	N$	3,140.00





Comparison of feeders supplying 2.5MVA (500m spaced equal loads). In towns Hare overhead distribution lines (at 11kV) should be utilized and are recommended in the master plan implementation. Long-term replacement of underground cables (if funds are available) is planned, especially in the town areas. [6]

[6] Cable rating:

Cable Type	Amps	MVA @ (11kV)
Zero Impedance Line 66kV		
Zero Impedance Line 11kV		
95mm CU XLPE	295	5.6
70mm CU XLPE	240	4.6
70mm CU PILC	200	3.8
50mm CU XLPE	200	3.8
35mm CU XLPE	170	3.2
25mm CU XLPE	140	2.7
25mm CU PILC	110	2.1
120mm CU PILC	270	5.1

5.5.1.2 Distributions stations –

Inclusion of distribution stations equipped with switchgear is imperative to realize an improved QoS (Quality of Supply) to customers –

Faults and system defects (occurring) can be isolated; faults can be easily located and rectified. Again, due to costs, as a first phase (year 0-5) only switching positions (RMUs) are recommended. – As second step, year 5-10, full distribution stations are recommended, replacing the RMU switching nodes. –

A key desire is that Lüderitz Town Council can control their own operation, and hence incoming breakers are required.

Distribution Station Upgrades are foreseen and planned in the CAPEX review/forecast.

5.6 Development plan –

The aim of the development plan – based on the current overview – is to always have a secure supply to the area, with minimal losses. The planned and future loads are critical to be accommodated, and the inherent loads must be supplied, with associated natural and accelerated growth.

Additional 'upgrade projects' such as replacing an overhead line with an underground cable are also listed in the project list. Street-lighting projects (as also identified at the stakeholder consultative meetings) have also been listed.

Priorities have been identified by a practical approach, and considering anticipated growth and projects being implemented in different areas.

5.6.1 Key activities are listed –

OUTLINE - Key upgrade areas have been defined as per shaded areas enclosed. In particular, the following for the first 3 years –

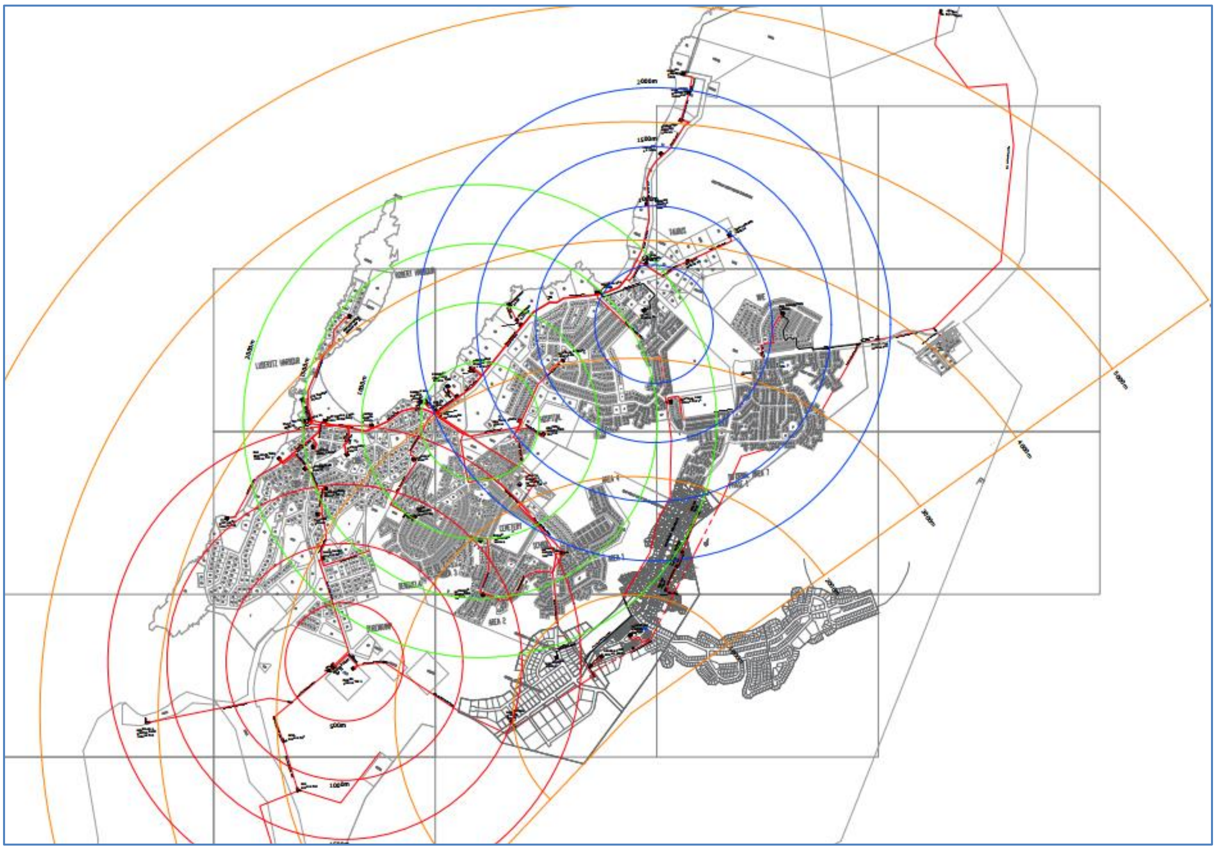
	Scope/description	YEAR
	Primary Stations	
1	Upgrade MAIN INTAKE - Protection upgrade and add 2 feeders	1
	the upgrade is required for protection / additional feeders, to extend the lifespan of the station to year 10. The station capability, if serviced, caters for 20MVA (1250A) - with eh current load at 6-7MVA - Metal clad switchgear to match existing will be sourced and installed.	
2	Upgrade ACC - New Load Centre Station - 2 Incomer / 6 feeders	3
	ACC needs to be repositioned and configured with 2 incomers and 8 feeders. Compact switchgear can be considered, due to its cost-effectiveness, all rated at 21kA fault level, IED protection will be facilitated	
3	New LOAD CENTRE - Zone 1…8 / Burenkamp- to accelerate load / southern development and densification strategy of LTC - avail industrial serviced land. - Building plus Compact Switchgear -	2
	Strategic planning earmarks southern town expansion, and a secure feeder and distribution in the area is required this will facilitate ring-feeds to NEST area, CBD, and Old Power station development / Namport, with increased redundancy,	
4	Upgrade and Extend - Nautilus (add double busbar / feeder infeed, extend to existing / replace with compact switchgear (2 infeed, 8 feeders)	2
	New feeder to Nautilus is provided 2024 FY - The distribution to be facilitated with a 2-busbar infeed and distribution.	

	PRIMARY LINKS	
1	MV Feeder from LTC NamPower Intake to ACC (Parallel 70 Cu Overhead or 150Cu XLPE) - Note: if OH - (as from 2030 upgrade to underground cable) - Ref. Year - NOTE_ Provide 1 Feeder and one sleeve for future second feeder (in trench - hard rock) - Supplement 70 HD CU.	1
	CBD/area redundancy and critical supply to be facilitated. Due to build up areas, a cable will be installed initially - with a sleeve in parallel to cater for a second future underground cable. Initially the existing overhead line will remain in place.	
2	MV Feeder from LTC NamPower Intake to NEW LOAD CENTRE At - Zone 1-8/Burenkamp - M - (Parallel 70 Cu Overhead or 150Cu XLPE) 95mm2 Cu - Note: if OH - (as from 2030 upgrade to underground cable) - Ref. Year - Provide supply node and ring-feed to NEST Hotel / Distribution	1
	Supply to new load centre, to accommodate nodal development in the southern part of Lüderitz	
3	MV Feeder NEW LOAD CENTRE Zone 1-8/Burenkamp - M - (as from 2030 upgrade to underground cable) - Ref. Year CABLE 120mm2	1
	Link between Primary and Secondary Station	
4	MV Feeder from NEW LOAD CENTRE Zone 5-8 to NEST / CBD area	2
	Link between Primary and Secondary Station - Provide n-1 redundancy to NEST hotel and PowerStation. Increase supply security to CBD	

5.6.2 Additional items -

- New Feeder and Load Centre – Ext ZONE 1-8 / Burenkamp Area
- Dengu Extensions linking to Burenkamp.
- Intake station – NamPower upgrade / supply cables, re-commission metering / feeders / terminations – REVISED STATION REQUIRED –
- Protection upgrade
- New Station (2030>)
- Nautilus suburb
- New Extension 7
- Feeder upgrade as indicated on the load-flow study / simulation.

Figure 31 : Upgrade areas.



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5.6.3 Activities –

KEY NODE S/S – SWITCHING STATIONS

Several switching stations are in place but not operational (i.e. solid) – this is to the detriment of the overall system security, operation ability and QoS (Quality of Supply).

- Minimal costs are required to upgrade these and to bring them online to their designed function.
- ACC S/S (Switching Station) Protection Upgrade / INTAKE PROTECTION UPGRADE / NAUTILUS S/S protection Upgrade.
- New Load centers/ extension
- Ensure many network nodes are available for switching procedures – these are mainly RMU (Ring-Main-units) in the short term (due to costs) and long terms Distribution stations with circuit breakers, which are costly.
- For overhead-lines ganged operated switches (load breaks) with high capacity are recommended to ensure the load as per conductor size can be switched – UNLESS – PREFERRED – DIRECT CONNECTION

5.6.3.1 Network re-enforcement plans –

These are defined over 10 years (i.e. short term up to 5 years) and medium term (5-10 years). – The current system (1020 baseline system is used as reference, from where projects are extended). – Natural and accelerated growth is considered – based on PSA (Progressive Settlement Areas) Developments (considered) and reference re *Table 3 : Spatial Load* Forecast */ Figure 8 : Load Node Demand Forecast* *(current, 5 years, 10 years)*. Supply feeders – emphasis is placed to close 'short' rings in the existing network, as well as to strengthen existing supply routes with additional (parallel) feeders.

Ring feeds around the towns are mainly overhead lines, as these can be constructed economically with ease.

5.6.3.2 <u>Street lighting –</u>

A key requirement as raised by is that **appropriate street lighting on key roads to be facilitated** – the implementation / funding will be arranged between the respective councils and Lüderitz Town Council. – The current state of street lighting is adequate and very good, presenting a good impression of the town.

Guidelines as per SABS 098 Part 2, as amended, are recommended as guideline – Traffic densities to be considered on respective designs, as well as costing, accessibility, and power availability – Detail costing for two design levels is included.

High-mast lighting is not covered under the key activities for upgrading the infrastructure but is covered under the PSA (Progressive Settlement Areas) electrification.

5.7 Tasks, Procedures and Upgrade paths

The Master plan – as focusing on the Distribution and Electrification components as major section, a few items as outlined below are revealed -

Based on SWOT (Strength, Weaknesses, Opportunity, and Threats) approach the system is summarized wrt. ensuring that system evaluation, critical weak points.

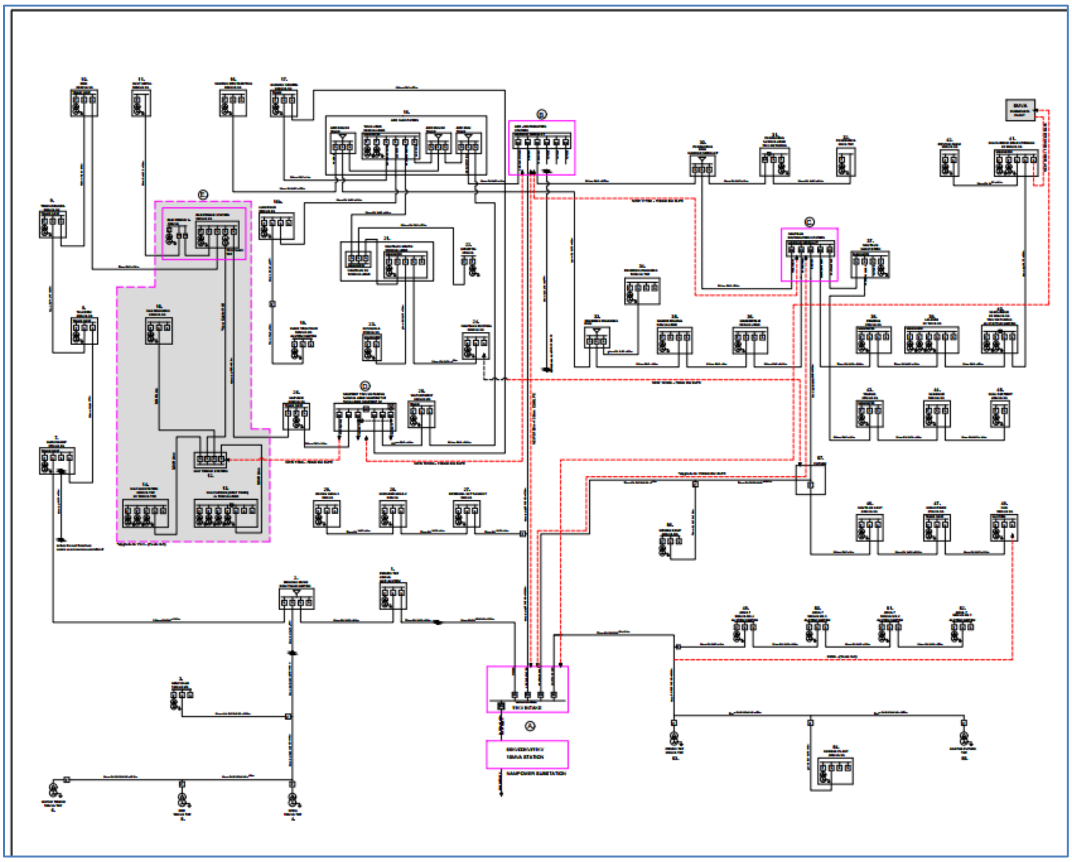
5.7.1 <u>Current Weaknesses and threats –</u>

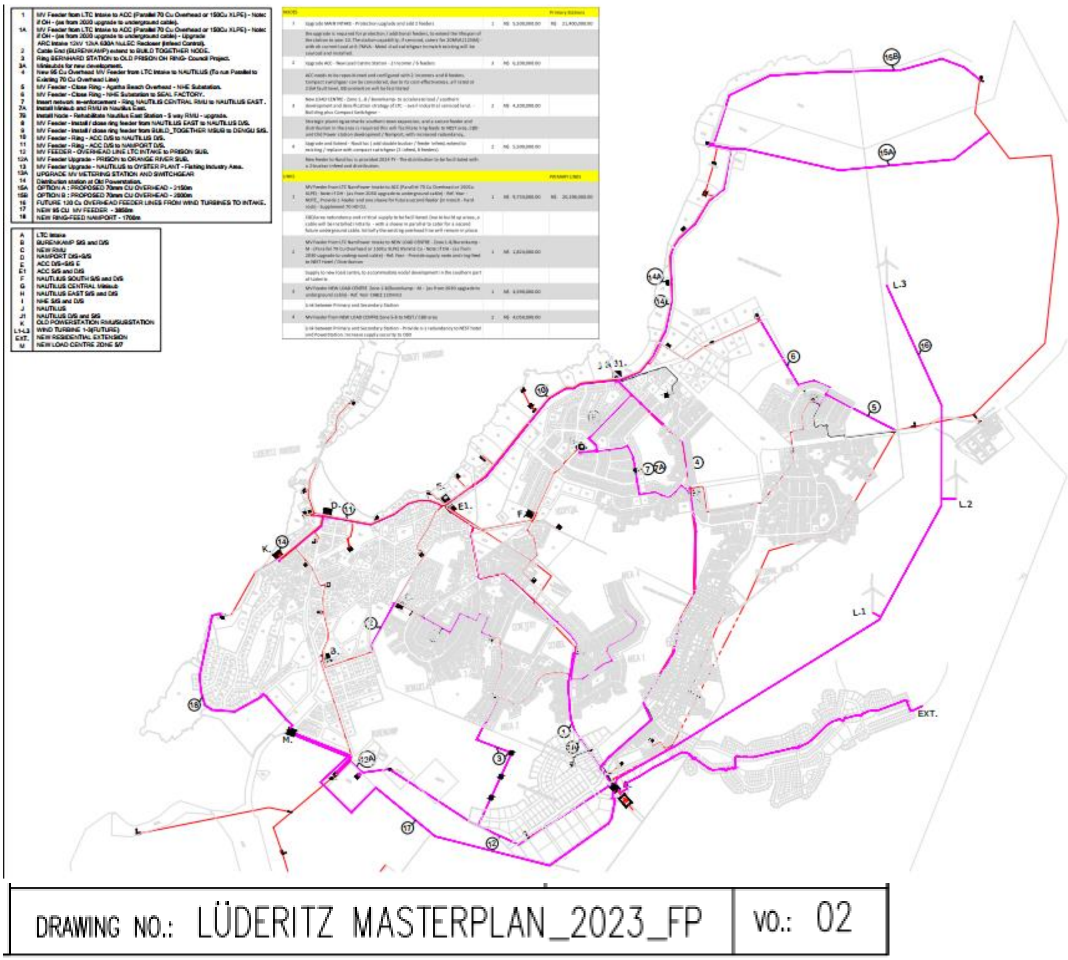
- Weak network points –
- No redundancy on the system (or very little)
- No Intake distribution station with adequate feeders and protection
- Inadequate feeders to supply the town – supply constraints.
- Inadequate switching points – old and need to be upgraded/replaced,
- Drop Out Fuses to be replaced. Corrosion proof nodes required.
- Magenfix RMUs pose an operational risk and danger – replace remaining.
- Existing distribution station and reclosers to be serviced (relays, batteries)
- Attend to all oil-leaks on bushings/ oil test, replacement.
- Proper routine maintenance and service plan to be implemented to ensure systematic servicing of all nodes – rather than ad-hoc crisis management.
- Old infrastructure requires maintenance and upgrade.
- Proper routine maintenance and service plan to be implemented to ensure systematic servicing of all nodes – rather than ad-hoc crisis management.

5.7.2 <u>Project costs –</u>

As the network development plan focuses on the MV (Medium Voltage) infrastructure key components have been identified and cost-values have been attached to determine the budget for the project implementation. – Refer to Project Cost components –12.3

Figure 32 : Proposed and considered key upgrade paths (SLD)





1	MV Feeder from LTC Intake to ACC (Parallel 70 Cu Overhead or 150Cu XLPE) - Note: if OH - (as from 2020 upgrade to underground cable).
1A	MV Feeder from LTC Intake to ACC (Parallel 70 Cu Overhead or 150Cu XLPE) - Note: if OH - (as from 2020 upgrade to underground cable) - *Upgrade*
	ARC Intake 12kV 12kA 630A NuLEC Recloser (Infeed Control).
2	Cable End (BURENKAMP) extend to BUILD TOGETHER NODE.
3	Ring BERNHARD STATION to OLD PRISON OH RING- Council Project.
3A	Minisubds for new development.
4	New 95 Cu Overhead MV Feeder from LTC Intake to NAUTILUS (To run Parallel to Existing 70 Cu Overhead Line)
5	MV Feeder - Close Ring - Agatha Beach Overhead - NHE Substation.
6	MV Feeder - Close Ring - NHE Substation to SEAL FACTORY.
7	Insert network re-enforcement - Ring NAUTILIS CENTRAL RMU to NAUTILUS EAST .
7A	Install Minisub and RMU in Nautilus East.
7B	Install Node - Rehabilitate Nautilus East Station - $ way RMU - upgrade.
8	MV Feeder - Install / close ring feeder from NAUTILUS EAST to NAUTILUS D/S.
9	MV Feeder - Install / close ring feeder from BUILD_TOGETHER MSUB to DENGU S/S.
10	MV Feeder - Ring - ACC D/S to NAUTILUS D/S.
11	MV Feeder - Ring - ACC D/S to NAMPORT D/S.
12	MV FEEDER - OVERHEAD LINE LTC INTAKE to PRISON SUB.
12A	MV Feeder Upgrade - PRISON to ORANGE RIVER SUB.
13	MV Feeder Upgrade - NAUTILUS to OYSTER PLANT - Fishing Industry Area.
13A	UPGRADE MV METERING STATION AND SWITCHGEAR
14	Distribution station at Old Powerstation.
15A	OPTION A : PROPOSED 70mm CU OVERHEAD - 2150m
15B	OPTION B : PROPOSED 70mm CU OVERHEAD - 2000m
16	FUTURE 120 Cu OVERHEAD FEEDER LINES FROM WIND TURBINES TO INTAKE.
17	NEW 95 CU MV FEEDER - 3850m
18	NEW RING-FEED NAMPORT - 1700m

A	LTC Intake
B	BURENKAMP S/S and D/S
C	NEW RMU
D	NAMPORT D/S+S/S
E	ACC D/S+S/S E
E1	ACC S/S and D/S
F	NAUTLIUS SOUTH S/S and D/S
G	NAUTILUS CENTRAL Minisub
H	NAUTILUS EAST S/S and D/S
I	NHE S/S and D/S
J	NAUTILUS
J1	NAUTILUS D/S and S/S
K	OLD POWERSTATION RMU/SUBSTATION
L1-L3	WIND TURBINE 1-3(FUTURE)
EXT.	NEW RESIDENTIAL EXTENSION
M	NEW LOAD CENTRE ZONE 5/7

5.8 Proposed Master-plan prioritised projects –

The required projects are listed. Financial aspects are dealt with in detail in the further section, especially wrt. the financing of these critical components. (**Drawing reference/ project description / budget / implementation year from 2025**)

The references refer to the MV (Medium Voltage) single line diagram / MV network drawing as planned for 2025. All projects to be referred to on the drawings.

(	Scope/description	YEAR	CAPEX	Column2
				Primary Stations
1	Upgrade MAIN INTAKE - Protection upgrade and add 2 feeders	1	N$ 5,500,000.00	N$ 21,400,000.00
	the upgrade is required for protection / additional feeders, to extend the lifespan of the station to year 10. The station capability, if serviced, caters for 20MVA (1250A) - with eh current load at 6-7MVA - Metal clad switchgear to match existing will be sourced and installed.			
2	Upgrade ACC - New Load Centre Station - 2 Incomer / 6 feeders	3	N$ 6,200,000.00	
	ACC needs to be repositioned and configured with 2 incomers and 8 feeders. Compact switchgear can be considered, due to its cost-effectiveness, all rated at 21kA fault level, IED protection will be facilitated			
3	New LOAD CENTRE - Zone 1...8 / Burenkamp- to accelerate load / southern development and densification strategy of LTC - avail industrial serviced land. - Building plus Compact Switchgear -	2	N$ 4,200,000.00	
	Strategic planning earmarks southern town expansion, and a secure feeder and distribution in the area is required this will facilitate ring-feeds to NEST area, CBD and Old Power station development / Namport, with increased redundancy,.			
4	Upgrade and Extend - Nautilus (add double busbar / feeder infeed, extend to existing / replace with compact switchgear (2 infeed, 8 feeders)	2	N$ 5,500,000.00	
	New feeder to Nautilus is provided 2024 FY - The distribution to be facilitated with a 2-busbar infeed and distribution.			

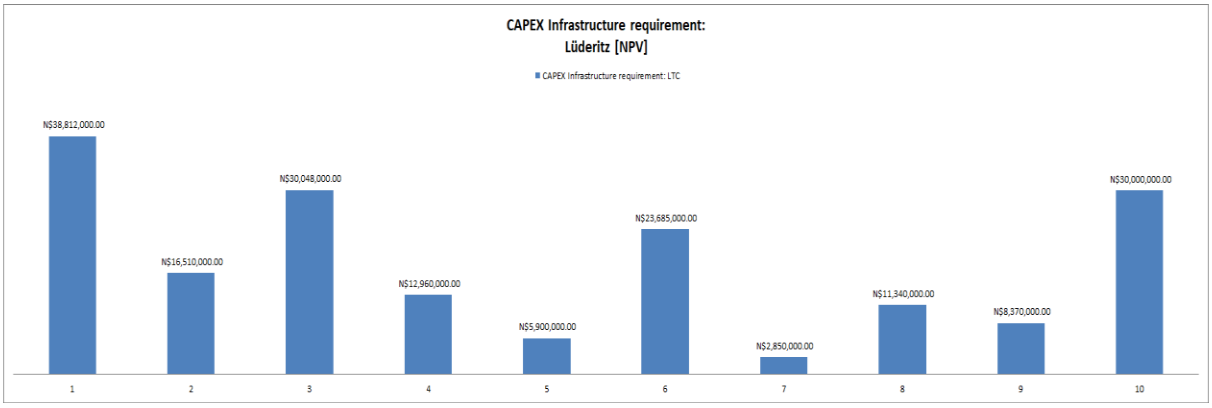
				PRIMARY LINKS
1	MV Feeder from LTC NamPower Intake to ACC (Parallel 70 Cu Overhead or 150Cu XLPE) - Note: if OH - (as from 2030 upgrade to underground cable) - Ref. Year - NOTE_ Provide 1 Feeder and one sleeve for future second feeder (in trench - hard rock) - Supplement 70 HD CU.	1	N$ 9,734,000.00	N$ 20,198,000.00
	CBD/area redundancy and critical supply to be facilitated. Due to build up areas, a cable will be installed initially - with a sleeve in parallel to cater for a second future underground cable. Initially the existing overhead line will remain in place.			
2	MV Feeder from LTC NamPower Intake to NEW LOAD CENTRE At - Zone 1-8/Burenkamp - M - (Parallel 70 Cu Overhead or 150Cu XLPE) 95mm2 Cu - Note: if OH - (as from 2030 upgrade to underground cable) - Ref. Year - Provide supply node and ring-feed to NEST Hotel / Distribution	1	N$ 1,824,000.00	
	Supply to new load centre, to accommodate nodal development in the southern part of Lüderitz			
3	MV Feeder NEW LOAD CENTRE Zone 1-8/Burenkamp - M - (as from 2030 upgrade to underground cable) - Ref. Year CABLE 120mm2	1	N$ 4,590,000.00	
	Link between Primary and Secondary Station			
4	MV Feeder from NEW LOAD CENTRE Zone 5-8 to NEST / CBD area	2	N$ 4,050,000.00	
	Link between Primary and Secondary Station - Provide n-1 redundancy to NEST hotel and PowerStation. Increase supply security to CBD			

Column1 Drawing Ref. No	Column2 Network Re-enforcement task	Column3 Cost	Column4 Year PIP
	BTU / Protection - NamPort	$ 600,000.00	1
14A	Upgrade Lalandii MV Metering and Switchgear MV metering to customer, relocate / new RMU / Demand Metering	$ 1,480,000.00	1
9	MV Feeder - Install / close ring feeder from BUILD_TOGETHER MSUB to DENGU S/S	$ 550,000.00	2
5	MV Feeder - Close Ring - Agatha Beach Overhead - NHE Substation	$ 1,100,000.00	3
6	MV Feeder - Close Ring - NHE Substation to SEAL FACTORY	$ 396,000.00	3
8A	Upgrade Nautilus D/S RMUs	$ 740,000.00	3
7	Insert network re-enforcement - Ring NAUTILIS CENTRAL RMU to NAUTILUS EAST	$ 1,430,000.00	4
7A	Install Minisub and RMU in Nautilus East	$ 860,000.00	4
10	MV Feeder - Ring - ACC D/S to NAUTILUS D/S	$ 3,060,000.00	4
11	MV Feeder - Ring - ACC D/S to NAMPORT D/S	$ 1,870,000.00	4
3	Feeder BH / Prison	$ 1,250,000.00	5
3A	Minisubs for new development Ext 4	$ 2,580,000.00	5
3B	RMU extension for new development Ext 4	$ 620,000.00	5
2	MV Feeder Extension from BURENKAMP to BUILD TOGETHER - 70 Cu XLPE to close the ring	$ 605,000.00	6
2A	Install RMU for node above (Loop into existing cable)	$ 310,000.00	6
12	MV FEEDER - OVERHEAD LINE LTC INTAKE to PRSION SUB	$ 720,000.00	6
15G	Distribution station at Old PowerStation	$ 950,000.00	6
15H	Circuit breakers - S/S Old PowerStation Supply to Nest Hotel / Local / MZ / Council	$ 5,000,000.00	6
8	MV Feeder - Install / close ring feeder from NAUTILUS EAST to NAUTILUS D/S	$ 1,100,000.00	7
12A	MV Feeder Upgrade - PRISON to ORANGE RIVER SUB	$ 550,000.00	7
4A	MV Feeder from LTC Intake to NAUTILUS (Parallel 70 Cu Overhead or 150Cu XLPE) - Note: if OH - (as from 2030 upgrade to underground cable)	$ 7,140,000.00	8
14	MV Feeder Upgrade - NAUTILUS to ABALONE PLANT - Fishing Industry Area	$ 3,400,000.00	3
1A	MV Feeder from LTC NamPower Intake to ACC (Parallel 70 Cu Overhead or 150Cu XLPE) - Note: if OH - (as from 2030 upgrade to underground cable) - *Upgrade*	$ 5,270,000.00	9

Item				
E1	Windpark Feeder	$	10,000,000.00	6
1	Metering: Ring Fence metering - Future WINDPARK	$	500,000.00	1
2	AMR (Automatic Meter Reading) - ToU (Time of Use) tariffs on MSBM impact	$	500,000.00	1
3	Lalandii - 11kV Metering	$	500,000.00	1
4	Nautilus S/S 150 Cu feed (parallel) upgrade to Abalone farm	$	3,000,000.00	1
5	Meter audit - TID rollover	$	3,000,000.00	1
6	DSM Ripple controller -	$	4,000,000.00	1
C	RMU - feeder to Build together	$	370,000.00	2
E	ACC station - upgrade and rehabilitate - *RMU* *LV Metering* *Trafo*	$	400,000.00	2
F	Nautilus new RMU / Switching and LV / closed bushing taro	$	400,000.00	2
H	Install RMU / Switches at Nautilus (Ring feed)	$	50,000.00	2
I	Install 4-way RMU at NHE -	$	50,000.00	2
J	Nautilus - Rehabilitate S/S - relays / metering QoS	$	200,000.00	2
J1	New RMU / switching	$	400,000.00	2
B	Burenkamp new switching node (Extensible RMU)	$	740,000.00	4
43				

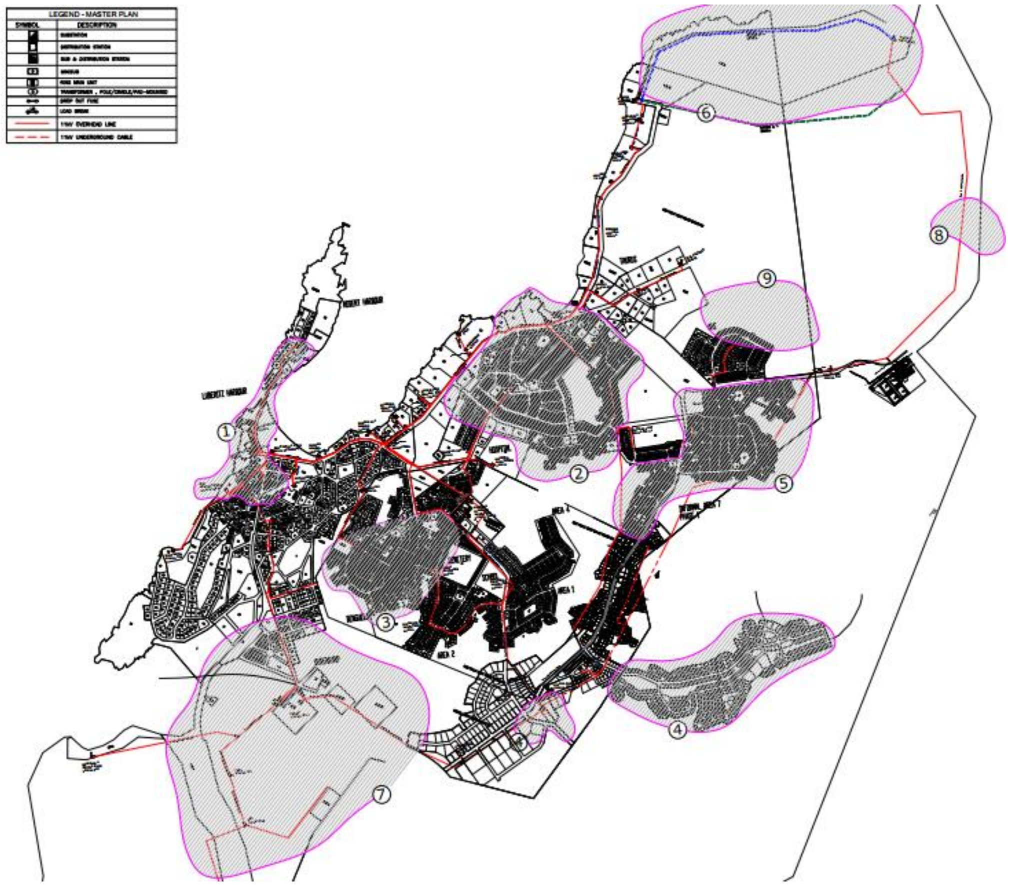
A total of approx. 50 projects are identified for implementation, with a total CAPEX of N$ 200 million. Implementation must be assessed in line with revised (dynamic) development requirements.

Figure 33 : CAPEX – 10-year PIP (Project Implementation Plan) – Infrastructure (present costs)



LÜDERITZ	**CAPEX Infrastructure requirement**	
Year 1	**Financial year 2024**	*$ 38,812,000.00*
Year 2	**Financial year 2025**	*$ 16,510,000.00*
Year 3	**Financial year 2026**	*$ 30,048,000.00*
Year 4	**Financial year 2027**	*$ 12,960,000.00*
Year 5	**Financial year 2028**	*$ 5,900,000.00*
Year 6	**Financial year 2029**	*$ 23,685,000.00*
Year 7	**Financial year 2030**	*$ 2,850,000.00*
Year 8	**Financial year 2031**	*$ 11,340,000.00*
Year 9	**Financial year 2032**	*$ 8,370,000.00*
Year 10	**Financial year 2033**	*$ 30,000,000.00*
		$ 180,475,000.00

Figure 34 : Proposed and considered key upgrade paths (map)



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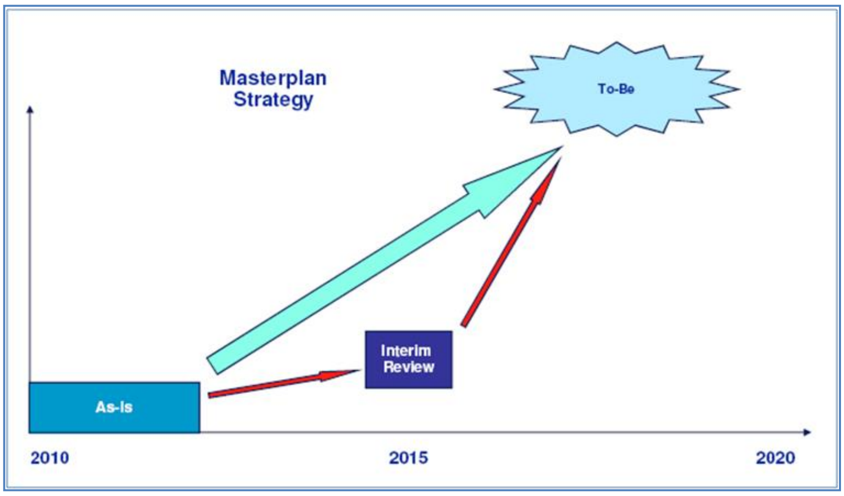
A southward development is favored, strategically and technically, by the planners.

5.9 Project progress re-assessment.

As per inception meeting (2022) Lüderitz Town Council, the continuous self-assessment on the performance wrt. milestones as set out above is essential, to compare progress made. Financial resources are key pre-requisites and must be taken into consideration regarding the ambitious distribution master plan.

Figure 35 : Master plan strategy –

A proper help to stay focused on the goal – which must be assessed from time to time.



5.10 OM (Operation and Maintenance) / rehabilitation issues –

Am expected aspect of the town's performance is the level of maintenance as well as preventative maintenance undertaken - Key tasks to improve and to prolong life of assets are listed – but not elaborated on as these are not part of the project -

5.10.1 General tasks required – **OM (Operation and Maintenance)**

- Implement a **systematic (preventative) maintenance schedule**, and compare to performance and desired status to actual status of the infrastructure –
- Repair and cleaning of all miniature substations (minisubs), making them fully accessible / pad lockable.
- Replace old (unsafe) magnefix switchgear units / transformers / metering units / switchgear
- Safety enclosures on all MV infrastructure
- Replace all open-bushing transformers
- Replace old LV boards
- Terminations of all cables to be checked / re-worked where age exceeds 10 years.
- Service all existing circuit breakers (older than 10 years) . Oil-change on all RMU's, Breakers and large transformers
- Installation of all safety labelling, fire extinguishers as required -
- Transformer / RMU service, including but not limited to checking and tightening all terminations, cleaning of oil leaks, replacements of seals etc.
- Transformer / RMU oil sampling, regeneration, and replacement as required, replacement of silica gel.

- Replacement of earthing installations, where copper was stolen, as well as making good all MV cable terminations.
- Replacement and refurbishment of all (old) LV Main Distribution boards in the sub-stations

Most transformers / Minisubs / RMUs have exceeded the age of being in service of 10 (ten) years and a full comprehensive service program must be implemented.

Specific tasks identified, which are to be covered under the OM of the annual budget.

	Electrcity	
	Amilema Installation of New 200 KVA Minisub Transformer	LTC
	Correction of Medium Voltage(11KV) Tie-In with DOF Assy	LTC
	Pamona Substation upgrade/replace Magnefix with RMU	LTC
	2nd Phase ACC Substation feeder upgrade to 120mm	LTC
	Seaflower Substation Revamp and Installation of RMU	LTC
	3rd Phase Prison Line Upgrade to 95mm	LTC
	4th Phase Agathe Beach Line Ring Feeder to the Factories.	LTC
	Nautilus Electrical Reticulation- ABC Removal	LTC
	ACC Station to Nautilus North Ring Feeder Repair/replacement	LTC
	Dengu Substation repairs.	LTC
	Recovery of rusted Street lights by way of a project	LTC
	Replacing Freddy Fisheries RMU	LTC
	ABC Line Replacement with Underground cable	LTC
	Nautilus South Substation to be re-constructed.	LTC
	Replacement of Old Transformers	LTC
1	Automatic Meter reading- TOU	LTC
1	Lalandi-11kv Meterig	LTC
1	Nautilus S/S 150Cu Feed Parallel Upgrade to abelone farm	LTC
1	Dsm Ripple Controler	LTC
1	Rmu Feeder to Build Together	LTC
1	Acc Subbstation- Upgrade and rehabilitate- Rmu	LTC
1	Nautilus New RMU/ Switching and LV/ Closed Bushing taro	LTC
1	Install RMU/ Switched at Nautilus (Ring Feed)	LTC
1	Install 4-way RMU at NHE	LTC
1	Nautilus- Rehabilitate S/S - relays/ Metering QoS	LTC
1	New Rmu Switching	LTC

Amilema Installation of New 200 KVA Minisub Transformer	LTC
Power Quality Collection for Each Substation	LTC
Amilema Build Together Houses Supply	LTC
Jackals Draai Minisub replace with Substation	LTC
Electricity Reticulation at Compound Blocks, Area 2	LTC

RE Project Component

6 Background – RE for Ludertiz

A key aspect of the Masterplan is the RE masterplan.

This report is presented, separately, but as an integral part of the Masterplan. Due to its significance, and required flexibility, it is enclosed as a stand-alone document.

6.1 Summary and infeed.

CHAPTER SUMMARY:

Lüderitz Town Council spent N$66.5 million on electricity purchases from NamPower during 2020, where 12% of the purchases catered for demand charges, at an LCOE of N$ 1.88/kWh. The MSBM promulgated in 2019, will allows for LTC to procure up to 30% of its electrical energy from sources other than NamPower, whilst allowing for NamPower to be the town's supplier of last resort.

Lüderitz area has one of the best wind resources globally with recorded annual wind speed of 8 m/s wind turbines erected in this area are anticipated to attain a capacity factor greater than 50%. Amongst all the renewable energy technologies considered, wind energy has proved to be the only viable and feasible technology for the area. **Adding a 3 MW wind farm to LTC's grid will save LTC N$14-18 million against its NamPower bill on an annual basis – based on current NamPower tariff**.

LTC can benefit from the participation and opportunities under the MSBMM, with also a net-export to contestable customers in the market, with provision of Wind Energy. This would provide a new dimension in LTC's revenue and operational model. It is expected that LTC can earn up to 1Mio in revenue under this consideration.

6.2 Background

Namibia has been cited as having some of the best renewable energy resources worldwide, with the best wind resources found in Lüderitz and surrounding areas. According to data obtained from the Global Wind Atlas (World Bank), the average wind speed recorded in Lüderitz and surrounding areas is 8.7 m/s with and average power density of more than 1200W/m^2 recorded in the Grossbucht area at IEC class 2 winds.

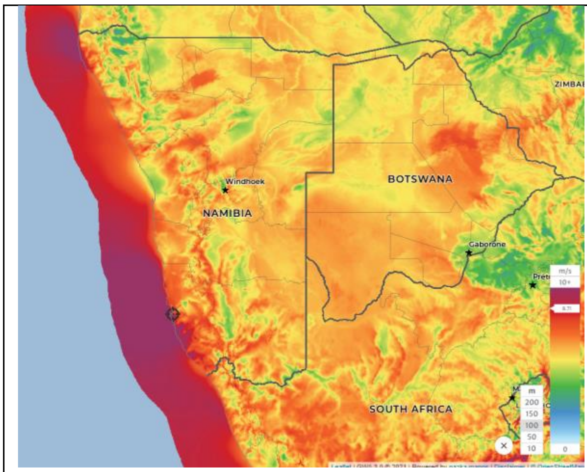


Figure 36: Lüderitz Average wind Speeds

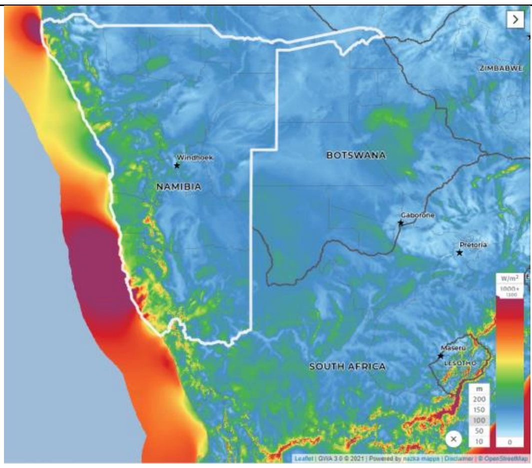


Figure 37: Lüderitz wind Power Density

Furthermore, the Lüderitz area is one of the only few geographical locations globally where land-based wind turbines can attain an average capacity factor of over 50%., the current average capacity factor of land-based wind turbines in Europe currently stands at 26% and 41.9% for offshore turbines. These parameters give an insight on the high energy generation potential of wind turbines.

6.3 Existing Supply

Lüderitz Town's electricity needs are currently met with a NamPower dedicated 7.5 MVA supply. The town council currently spends N$ 66.6 million to serve the electricity needs of the town on an annual basis (based on 2020 consumption). In 2020, 12% of Lüderitz Town's electricity bill catered for demand charges.

6.4 Enabling Policies

The Namibian government through state agencies such as the Ministry of Mines and Energy and the electricity regulator (ECB) have developed several policies that encourage the development and integration of renewable energy sources into Namibia's national grid to diversify the country's energy mix and further enhance the use of sustainable energy systems. Listed below are some of the policies that encourage the development of renewable energy systems within Namibia.

6.4.1 National Renewable Energy Policy

Provides guidance on the development of the Renewable Energy sector and scale up contribution from renewable sources in Namibia's electricity mix.

6.4.2 National Integrated Resource Plan

Promotes the notion of distributed generation – potentially reducing the technical and financial challenges associated with delivering small amounts of power across a large area.

6.4.3 National IPP Policy

Streamlines the IPP regime in the country and promotes investment of domestic and international investors into the Namibian power market.

6.4.4 Modified Single Buyer Market Model

Enables Investment in the energy sector and facilitates competition and stimulates economic growth.

6.4.5 Public Private Partnership (PPP) Policy

The policy is an initiative by the Namibian government to enhance the participation of private investments in areas that encompass the development of economic, social, municipal, and industrial assets within the public domain.

6.4.6 Namibia Renewable Energy Grid Code

The code stipulates the minimum technical performance and design requirements for renewable energy power producers that seek to connect to distribution or transmission networks within Namibia.

6.5 detail report, -

6.5.1 as separate entity – is enclosed.

Report¶

Lüderitz·Town·Council·VRE·Integration·Study·–·LTC·Master·Plan·2021¶

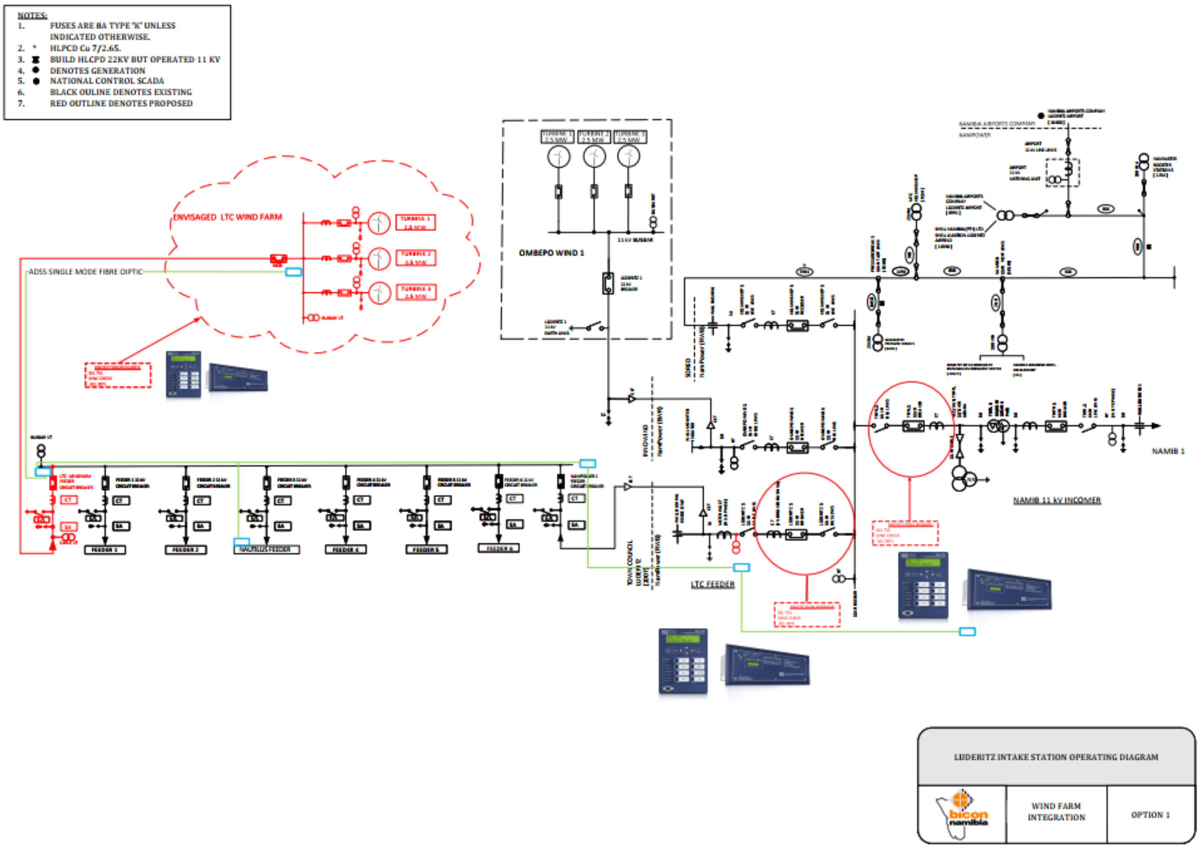
Lüderitz

6.5.2 Homer Grid Simulation

Distributed· Generation· Proposal¤

PREPARED·FOR:¶
Luderitz·Town·Council,·Municipality
Tal·St,·Luderitz,·Namibia
¶
PREPARED·BY:¶
Jochen·Roeber,·Pr.·Eng
Your·Company·Name,·roeber@gsfa.com.na
+264·81·1287892¤

6.5.3 Network Integration options



QoS (Quality of supply) DSM (Demand Side management) / Metering issues and perspectives

CHAPTER SUMMARY:

DSM issues and perspective

Profile	The town of Lüderitz's load profile has a load factor of approximately 56%, which is reasonably good. However, very dominant morning and evening peaks are observed.
Loads	From statistics and surveys available, the geyser penetrations yield 1000 to 1200 controllable loads. (From Profile, 600kW can be controlled)
DSM	It is estimated that (based on a 65% ratio), 0.6 MVA can be controlled to yield the desired load shifting and hence demand cost benefit –
Saving	Annual savings of approximately N$ 700,000.- to 800,000.- can be materialised., resulting in a feasible (bankable) project. –
PFC	Power factor correction, even though marginal beneficial, is not recommended at this stage.
AMR / ToU	AMR (Automatic Meter Reading) ToU (Time of Use) tariffs were implemented successfully as a parallel project to the masterplan.
QoS	QoS is deemed to be within requirements. It is assumed that low voltages on feeders are experienced. – Monitoring is required in line with ECB requirements.
NENA Asset	The network assets based on NENA are 46 million for the replacement cost, and 20 million book-value, from which annual depreciation is reflected.

7 QoS (Qulaity of supply) DSM (Demand Side management) / Metering issues and perspectives

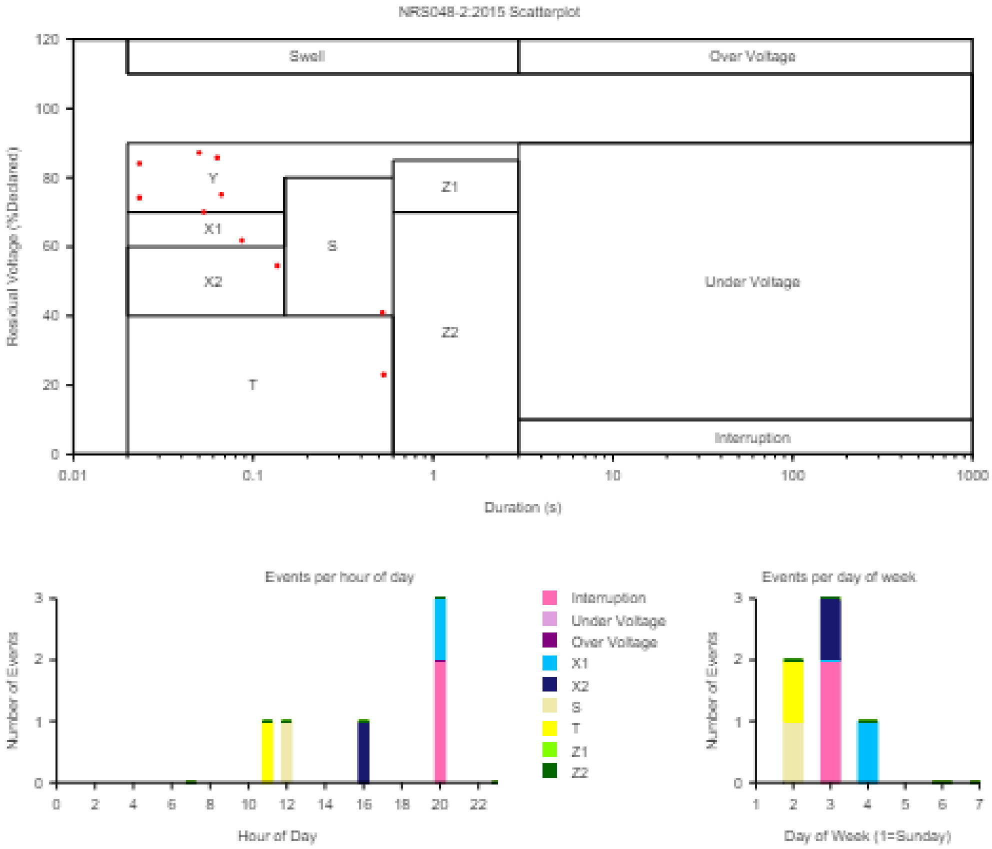
7.1 QoS issues –

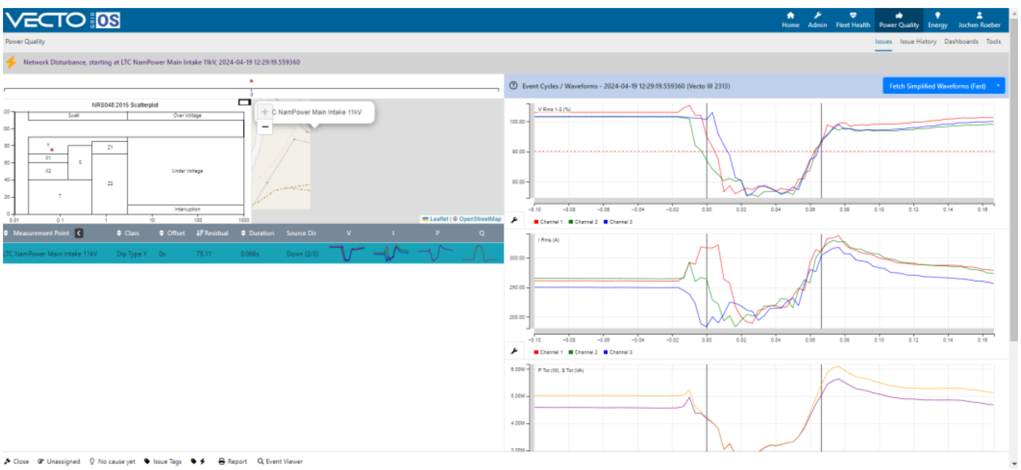
7.1.1 MV (Medium Voltage 11kV) QoS (Quality of Supply) issues

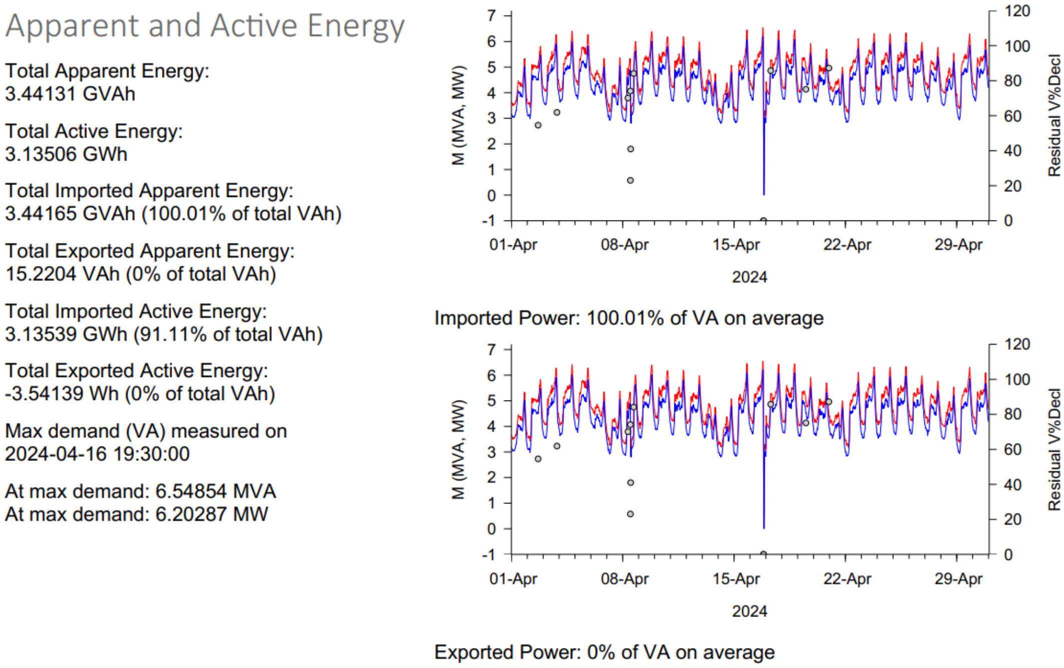
As per ECB QoS (Quality of Supply) project, Lüderitz Town Council is leading amongst the RED (Regional Electricity Distributors) s on QoS assessment. – No devices are populated in the Lüderitz Town Council distribution area, recording the supply quality according to NRS 048. For Lüderitz, one VECTO3 Class 1 QoS logger / meter is installed on the NamPower incomer.

Results, the QoS for Lüderitz is good, and minimal events and quality of supply issues are recorded. Mostly events stem from the upstream NamPower supply, impacted by (most likely) windfarms on regulation issues. Monthly reports on QoS are presented to the Regulator and LTC management.

Figure 38 : QoS dip and swell plot – Lüderitz.







Source: GSFainsinger ECB QoS project

7.1.2 Overall assessment

The overall assessment is reasonable to good – and no major outages and interruptions are reported, - in reference to the *Network Philosophy, Redundancy and Reliability analysis* – the network reliability is good[7].

7.1.3 Analysis – QoS

It is recommended to continue with the QoS solution - QoS recorders in town to continuously assess and monitor network performance –

For LTC (Lüderitz Town Council) are 3-4 QoS loggers / VECTO3 should be installed to get a good cover of the area

Budget is provided.

7.2 DSM (Demand Side Management)

7.2.1 DSM (Demand Site Management)

To analyze options for the DSM, information on key attributes of the area is required- i.e. overall annual and detailed **load profiles**, **consumer categories** and controllable (manageable **loads**) -

DSM (Demand Site Management) as per national study conducted by the ECB [8] recommended various option, of which several have already been implemented. Ripple control to date has not been implemented because of the study, (only existing systems in Windhoek and Walvisaby are operational), as this is perceived most likely as an expensive and skills intensive solution. –

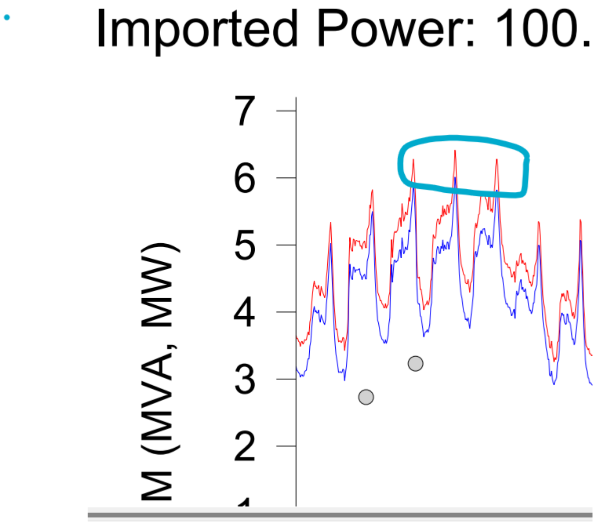
The master plan addresses the issue and evaluates the cost/ benefit for implementation. Ripple control for DSM can be considered for Lüderitz – based on the overall load profile as well as the assessment of

[7] Refer to report NAmPower info / QoS.

[8] DEMAND SIDE MANAGEMENT STUDY FOR NAMIBIA REPORT 1: OVERVIEW OF DSM OPTIONS AND RANKING FRAMEWORK – ECB, May 2006

the residential load profiles. – The overall profile (Town In feed) is applicable, as this is the metering / billing interface to NamPower.

Figure 39 : DSM - Weekly Profile (2024)

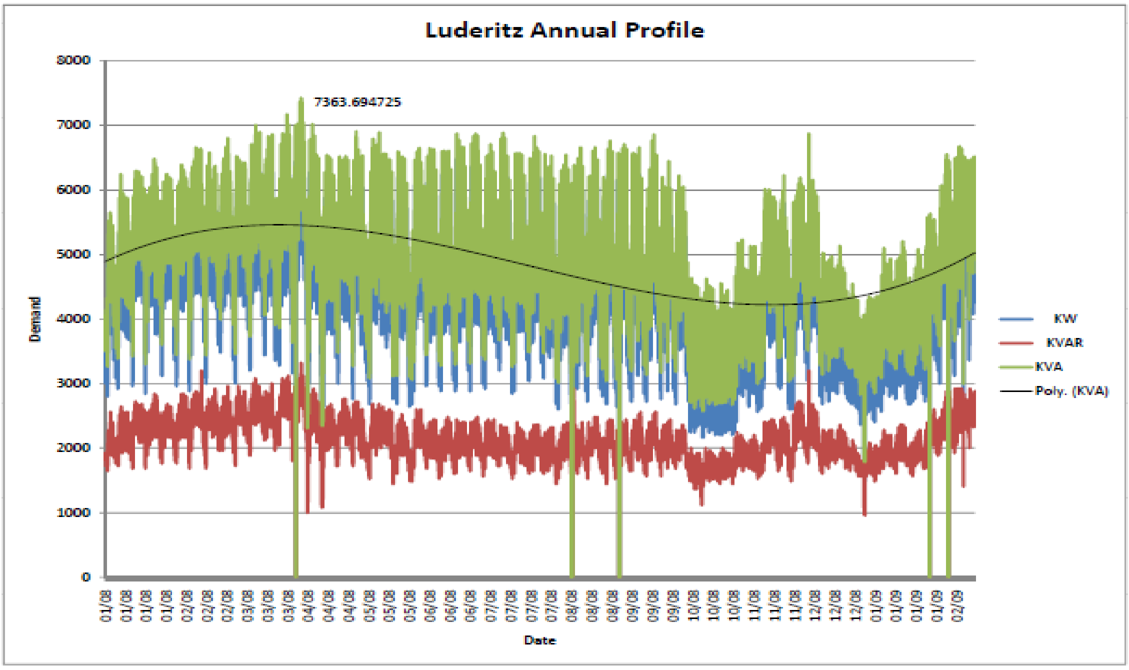


A dominant (daily) residential peak () and evening peak are present – The assumptions for the DSM (Demand Side Management) ripple control (for geyser load shifting / control) are that the overall peak demand can be reduced, and energy purchases can be moved from Peak to standard tariffs. – Winter and Summer seasons are considered. –

The total recorded MD is 6.7MVA (refer to AMR system).

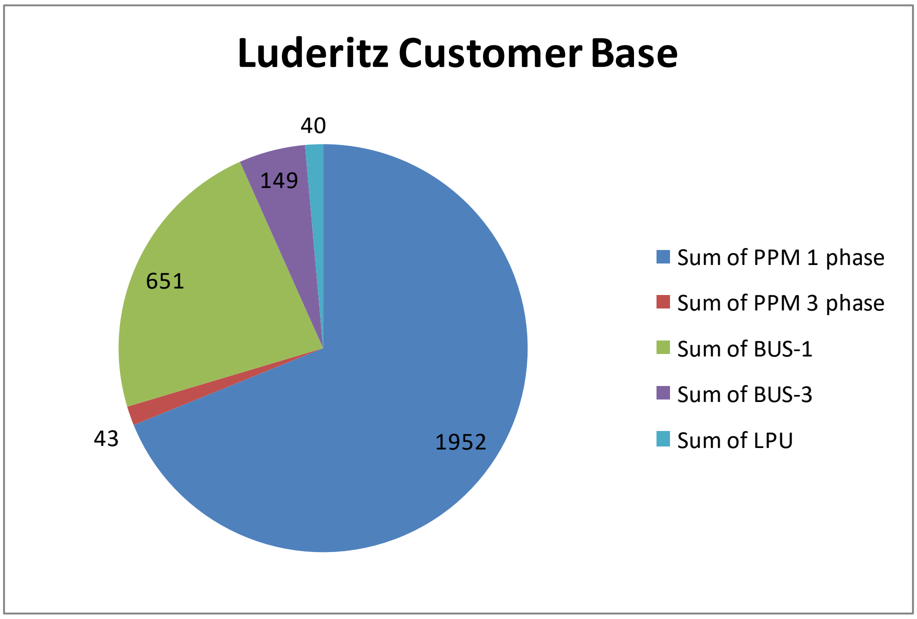
This would provide for a tariff incentive to offset the total NamPower MD and Access charge bill.

Figure 40 : DSM - Annual Profile



A critical aspect is the availability of Controllable loads – and hence the determination of e.g. Geyser penetration. Typical residential impact and the level of electrical hot water geyser penetration must be confirmed. This is based on a statistical approach.

Figure 41 – Customer / client base categories – based on number of customers per category and reference to residential load profiles.



LUDERTITZ - Customer base	Data	TOTAL	2835		
Locality	Sum of PPM 1 phase	Sum of PPM 3 phase	Sum of BUS-1	Sum of BUS-3	Sum of LPU
Lüderitz	1952	43	651	149 * incl	108 *
(Percentage	69%	2%	23%	5%	1%

Source: [9] ORM

See LPU Summary - It can be assumed (based on statistical info) that Lüderitz would have approximately 800 to 1000 controllable loads installed – and most of these would be geysers (HWSG) Hot water storage geysers.

7.2.2 Ripple control solution (overview) / Peak Shaving.

7.2.2.1 Cost/benefit

An initial cost estimate, including controller, coupler, and injector, would cost N$ 700,000. - The individual installation for each household (controller) can be estimated at N$ 1,000. - per load.

As outlined below – the Capex for a local system is in the region of N$ 1,000,000. – whilst the annual saving is estimated at N$ 1000,000.- to N$ 1.500,000. -(all stated in present values) – a payback period of 2 years is predicted, making the project feasible, even if it must be bank financed.

- adequate numbers of controllable loads
- direct NamPower supply point
- payback period less than 2 years
- geyser penetration is adequate

[9] LTC (Lüderitz Town Council - Technical Services) Nena asset register / energy sales / ORM (Operating and Reporting Manual)

7.2.3 BESS

An alternate option, as indicated under the RE project- would be BESS (Battery) storage and peak injection.

7.2.3.1 Conclusion

Annual saving, based on a minimum reduction of 1 MVA (conservatively estimated) would yield a significant annual saving. A detailed study to be commissioned.

7.3 NENA Asset register

The towns' assets were surveyed and placed / entered the NENA database. – the results were obtained, based on the ECB consultants 'assessment.

NENA ID	Asset Information (ID; Net ID, Description)	Asset Type	Locality	Qty	Units	Age Years	Replacement Cost	Book Value	Life Left
		Luderitz	SUBTOTAL				81,423,818	27,681,405	34%
		REPORT	TOTAL				81,423,818	27,681,405	34%

Shashi 2020 Data

Key Point- ORM data with upgrades to be reviewed.

7.4 Powerfactor

The power factor for the town is satisfactory.

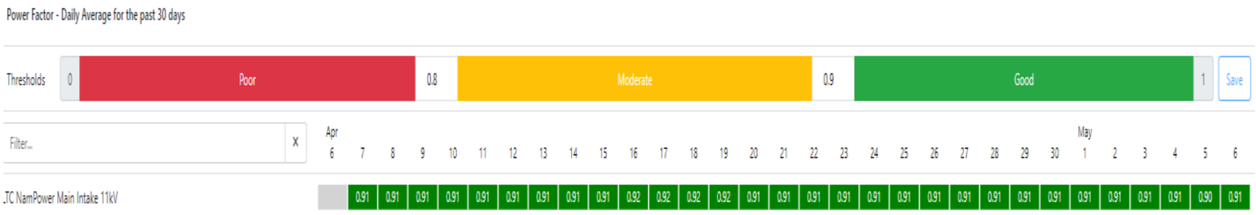


Figure 42 : POWERFACTOR summary / April 24

Electrification Masterplan – Densification and Extension Part

CHAPTER SUMMARY:

Immediate need for development and vision 2030.

Industrial and commercial erven and entities

Areas is the town have been identified for informal settlement electrification – and defined as low and very low income areas – with income per household (total) of approximately N$ 1000. – per household

The demand is estimated at 0,75kVA per household. – Current PSA designs overestimate the demand by far, hence overcapitalising projects.

Several low and low cost areas have been defined, with approximately 2000 stands. –

The average household size of 5 members would yield benefits of electrification to over 10,000 persons in the medium 10 year future.

The total capital required to service all selected 20 areas 200 Million N$. – The projects are spread over the timeframe of 10 years. – Grant funding is essential to facilitate the realisation of projects on PSA (Progressive Settlement Areas) electrification.

8 Electrification Planning for PSA (Progressive Settlement Areas) / Informal settlement areas

8.1 Overview

As outlined in the introduction, shift in terms of electrification requirements from rural to urban (peri-urban) areas are clear –

The urban shift (due to migratory patterns) places ever increasing expectations on Lüderitz Town Council. The report can be submitted by Lüderitz Town Council for submission to the MME (Ministry of Mines and Energy) and stakeholders re. future of electrification planning during 2025. This report however only focused on several localities in the respective town, whilst the current master plan focuses on all PSA (Progressive Settlement Areas) at stake in the area.

In terms of the Electricity Act of 2000, as amended in 2007, government via the ECB (Electricity Control Board) strives to achieve efficiency in the energy sector.

As per government objective as well as the objective of the Vision 2030 – which is Namibia's development objective in terms of growth, development, self-sufficiency, education, health etc. - a key priority and objective is to provide affordable electricity to most of the urban and rural population, also to act as catalyst for economic growth, social development, up-liftmetn and progress. The 2004 Rural Electrification masterplan indicates that based on the 1999 national population census only 52% of urban households in the Lüderitz Town Council license area have access to electricity. This application aims to reach the remaining 48% of urban households without access to electricity, which are overwhelmingly also the most marginalized communities.

The rural / PSA (Progressive Settlement area) of the areas needs electrification, and as proven from Socio-Demographic surveys, both political and economic (socio-economic) aspects justify the electrification of the area. Electricity is an identified key catalyst for economic growth and development progress in any society.

With the implementation of the RED (Regional Electricity Distributors) – the (electrification) function has become the responsibility of the REDs in terms of their license agreement, and the RA's / LA's and municipalities are key shareholder of the RED as established company. Hence it is essential that a common goal between all stakeholders is reached, to ensure that PSA (Progressive Settlement Areas) and Informal settlement areas gain access to electricity i.e. are electrified in a proper and systematic manner. For LTC (Lüderitz Town Council) – no RED is in place, and electrification responsibilities lie with the council.

For the Lüderitz Electrical Masterplan 22/33 - 24/25 – Electrification section, only zone R3 and R4 (low-income areas) are selected as viable projects qualifying for grant funding, as these are occupied by the more marginalized population, and the focus in the masterplan is based to ensure these populations can be facilitated with access to grid electricity.

8.1.1 PSA (Progressive Settlement Areas) zones

The zones R3 and R4 are the typical low-cost shack-dweller association project, build together areas and PSA (Progressive Settlement Areas) respectively.

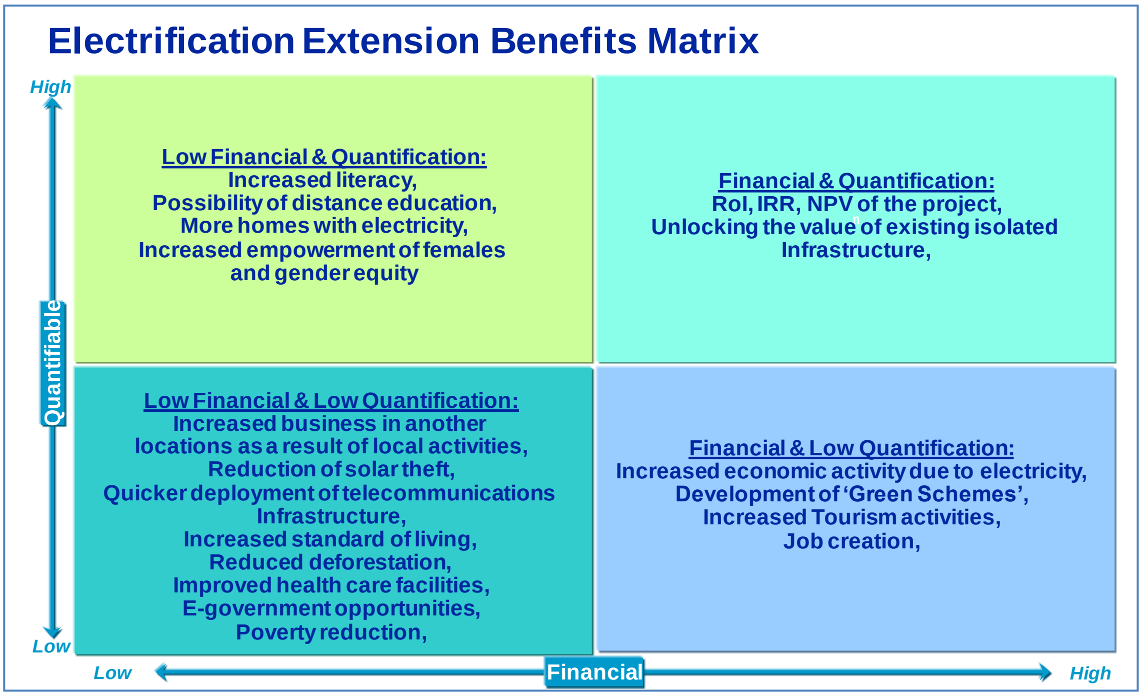
8.2 Key motivators:

Listed below are a few of the many benefits brought forward from electrification projects.

1. Immediate project benefits
2. In-line with government objective for Namibia Vision 2030
3. A large population reached with benefits.
4. Low cost per connection to be achieved.
5. Immediate success addressing socio-economic problems.
6. Job creation and training / skills transfer through the electrification project.
7. Education / health / safety benefits through electricity
8. Need of electricity
9. Available disposable income to pay for electricity.
10. Reduced negative impact on the environment e.g. through de-forestation.
11. Generation of business opportunities with the availability of electricity (welding/ sewing/ shops/ etc.)
12. Political gain by fulfilling promises and showing good governance.
13. Economic viability, based on positive cash-flow that can be generated (disposable available income for energy sources) that can pay for the development.
14. irrigation projects can be started.
15. enhance health delivery – clinics are planned.
16. education – schools and kindergartens are planned and need access to electricity for proper operation.
17. platform for e-Government
18. access to telecommunications, internet, etc.

8.2.1 Benefits matrix –

Figure 43 : Benefits matrix.



As several benefits (financial) can be quantified, others cannot be quantified. – the table above outlines the respective quantification of benefits. – Electrification of low-income households has – as shown – many benefits that will produce positive effects on the economy in the medium term only. -

8.2.2 Requirement.

Electricity, a feasibility study containing references to the following points as outlined hereunder has been proposed.

1. Technology options for implementation of electrification (least cost solution, but to proper and safe standards)
2. Design methodologies – calculation approach.
3. Load estimate / Load zones / load forecast / Load research (Namibia)
4. Financial cost / budget estimate
5. Benefits -
6. Economic indicators

8.3 Technical approach

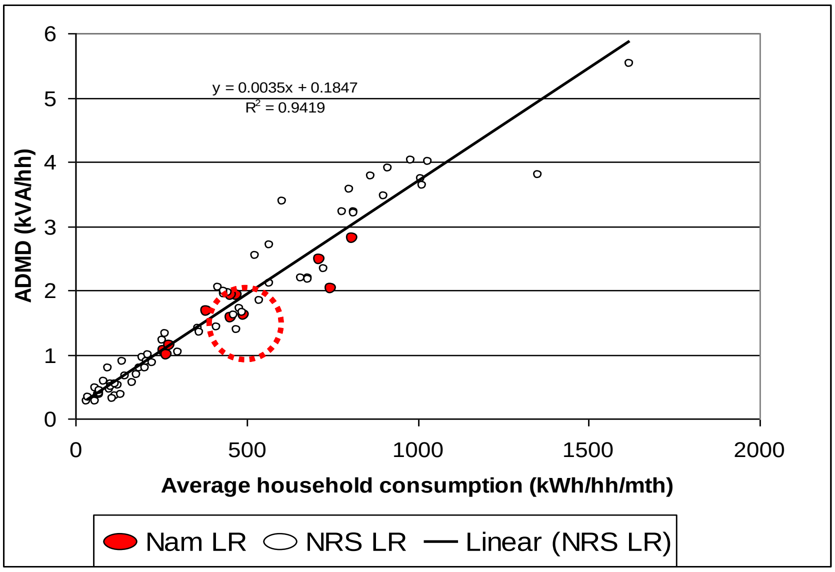
8.3.1 Planning

An overall approach to catering for present and future needs must be addressed in terms of demand and network expansion. A standard requirement is to have adequate supply rings (n-1) scenario, i.e. each transformer can be supplied from two feeders. In this case it is recommended that it would not always be required to limit the costs.

8.3.2 Load Research

A critical factor for the design is to determine the expected load to design the electrical distribution network for.

Figure 44: NRS load research information on Demand / energy aspects Domestic Admd vs. Consumption: Namibia vs. South Africa LR projects[10]



The NRS Load Research project, as conducted by the MME (Ministry of Mines and Energy), GTZ and PoN (Polytechnic of Namibia), key factors affecting the demand and energy consumption, is the income of the household. Further, running water (absent) and house structures as well as hot water geyser penetration play a major impact.

1. **@ 0.88kVA ADMD**, a=0.416, b=2.327, c=25A - the average consumption at 200kWh/hh/month

(25A CB)

2. @ 0.53kVA ADMD, a=0.355, b=3.487, c=25A – the averages consumption at 100kWh/hh/month

(25A CB)

8.3.3 Design criteria

Load calculations are based on an average 100 kWHr sold per month, as well as a 25A circuit breaker installed, and supplied via a ready PPM (Prepayment Meter) / ready board. This would allow for a special arrangement and tariff that shops could be upgraded to 60A.

This is the 'worse' case scenario and would allow for additional safety for the network design.

8.3.4 LV (Low Voltage 230/400V)

The second component, the LV (Low Voltage 400V) distribution will be based on approved ABC (Aerial Bundled Conductor) technology, and possibly mid-block construction. This yields very cost reflective structures, and lines will be constructed on the border centerline between adjacent erven back-to-back. The benefits are that shorter poles can be used, and service connection cables are short.

[10] Based on recommendations of S. Antindi (GS Fainsinger and Associates Engineers, Ongwediva, Load Research coordinator) the following approach has been followed.

8.3.5 Service connections

The third and last project components, i.e. the service connections, are made to supply power to the customers.

The cost is based on the following estimates.

PPM (PrePayment Meter) / Readyboard / cable (airdac) N$ 3,000. - connection

For simplification, an electrification cost/per erf approach has been followed, based on respective income groups -

Scheme		Group-Zoning	Order-Space Utilization	Special	Attribute on Income [2024 reference] / Activity
		Zoning	General description		estimated income per household -
1	R1	Residential	High Income		>N$45,000
2	R2	Residential	Medium Income		N$30,000-N$45,000
4	R3	Residential	Low Income		N$15,000-N$30,000
5	R4	Residential	VeryLow Income		N$3,000-N$12,000

For further calculations, the S-curve load growth approach is considered, allowing a steady increment in the load for zones R3 and R4. – The saturation is estimated at 0.75kVA ADMD.

8.3.6 Socio-Demographic site assessment

To ensure proper planning, especially wrt. To the TEMP (Town Electrification Extension Masterplan) can be facilitated, a good understanding of the clients i.e. electrification area is required.

The need and want for electricity are on hand, but the **REAL need** must be verified, in terms of **affordability and sustainability** of electrification projects –

Detailed and proper HES **(Household Energy Survey)** should be conducted in key areas, to determine the feasibility of electrification projects –

Requirements as stipulated by the EIB (European Investment Bank) have been considered. – The aim is to facilitate a business plan and PIP (Project Implementation Plan) for designated areas of the town –

8.3.7 Project Household Energy Survey

Purpose – the HES is conducted to determine –

- The **NEED** for electricity
- The **ACCEPTANCE** of electricity
- The **AFFORDABILITY** of electricity
- To define the ultimate **BENEFIT** of electricity in the area

8.3.8 Approach

For successful planning and design of an electrification project, a detailed assessment of the area under investigation and proposed for electrification must be made. Lüderitz Town Council has done a detailed () socio-demographic study for the area, as well as additional surveys (GIS / mapping). Further, GPS surveys, surveys, aerial photographs were used as supporting information and data.

For the LTC project, common assumptions were made.

8.3.9 HES (Household Energy Survey) Income / expenditure survey

Socio-demographic survey data, key indicators that must be determined are the following.

1. Total population for the area PSA (Progressive Settlement area), as relevant for this study.
2. Total income per household for the area, and employment statistics for revenue generation.
3. Total expenditure on energy for the area (considering summer and winter months) – for winter months a higher energy usage is predicted due to climatic influences.

It can be assumed that of the total money currently allocated to purchase energy sources such as **wood (as available), LPGas, candles, batteries, paraffin etc.**, a substantial part would be **available to purchase electricity**.

As per survey conducted, the PSA (Progressive Settlement area) under investigation is a homogeneous area – and has very similar socio-demographic patterns, hence 'regional' conclusions can be drawn.

Results are based on a total of samples in the area, and based on a statistical sample this is acceptable to draw wide-ranging conclusions.

Figure 45: Demand groups for analyzing informal settlement electrification.

	Scheme		**Group-Zoning**	**Order-Space Utilization**
			Zoning	General description
1	1	R1	Residential	High Income
2	2	R2	Residential	Medium Income
3	4	R3	Residential	Low Income
4	5	R4	Residential	VeryLow Income
5	6	IS	Institutional	Government offices
6	7	BC-L	Business/Commercial	Low Density
7	8	BC-H	Business/Commercial	High Density
8	9	BP	Plots	Business
9	10	BA	Plots	Agricultural
10	11	IND-L	Industrial	Light
11	12	IND-H	Industrial	Heavy
12	13	Z1	Future	mixed

Demand groups for planning purposes are outlined as in above table –

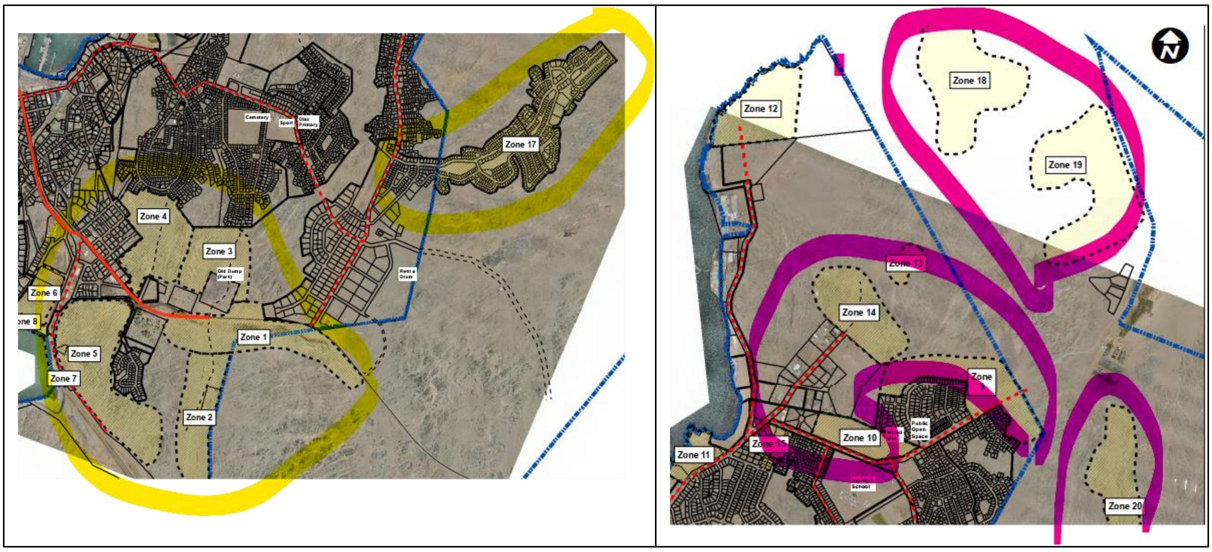
9 Electrification of Development Areas , Densification approach–

Development areas designated for PSA (Progressive Settlement Areas) / Informal settlements have been identified at the individual stakeholder meetings in the different towns at stake – Town planner's layouts have also been consulted to verify to a matching extend the intended land-use areas as designated. -

For Lüderitz the key emphasis has been placed on the areas of **Extension 2/7/8**–

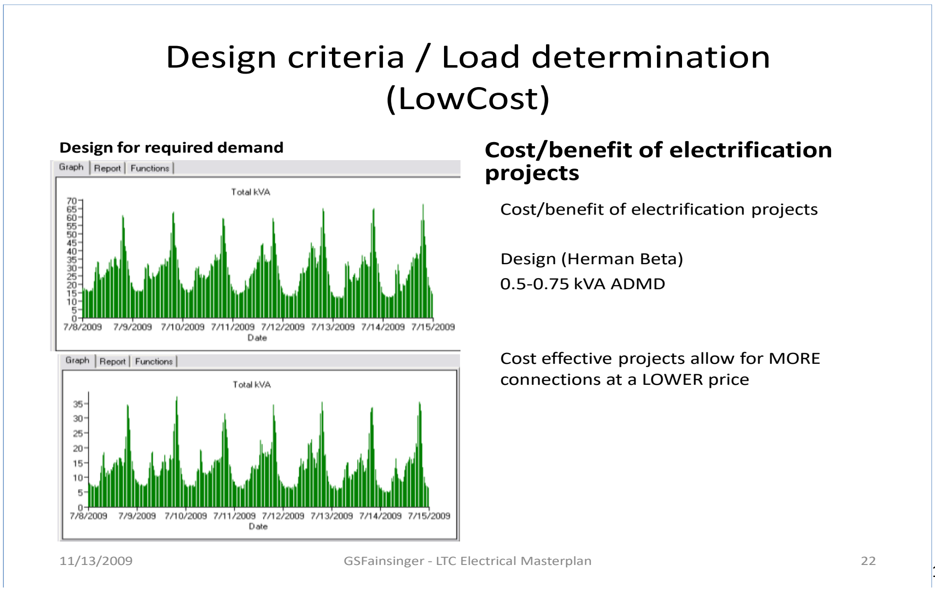
Requirements are areas that are NOT yet electrified at all – for consideration in the financial / economic model - In a separate project, or as variation / additions to the adjacent projects, barrier removal concepts can be introduced to facilitate the connection of households that have ACCESS to electricity, but not the means to pay the deposit / connection fee. –

Figure 46: PSA (Progressive Settlement Areas) electrification areas and densification project.



Refer to detailed layout map in the report: Design criteria for the TEMP (Town Electrification Masterplan). The guideline is based on the HB (Hermann Beta, NRS 034) method, for load / voltage profile calculations – A detail analysis and coefficients is attached in the Appendix 12.2.1.

Figure 47: Demand – Extension 7



[11]

A demand of about 30 – 70 kVA is recorded per installed minisub of 500kVA. These facts are key requirements for cost-effective electrification projects. –

9.1.1 Design criteria / Load determination (Low Cost)

0.5-0.75 kVA ADMD - Cost effective projects allow for MORE connections at a LOWER price.

9.2 Town development and development areas –

The masterplan focuses on the **LOAD** and hence **ELECTRICAL** masterplan, and zones have been defined, aligned to town-planner's zonings –

The TEMP (Town Electrification Masterplan) focuses on the low and very low-income residential areas, and hence more detail is provided for the anticipated load requirements and details –

For town electrification projects – grant funds will be available for the marginalized population, i.e. least cost electrification solutions. – Commercially viable projects e.g. financed from developers and NHE are not considered, as these are regarded as up-market developments. –

These are of course considered for the load-growth and expansion.

Electrification projects envisaged are these in **PROXIMITY ACCESS**[12] of electricity – i.e. within 10km from existing distribution infrastructure, whilst **ACCESS** is defined where the connection is within 500m of electrical infrastructure. For the masterplan this guideline is adjusted, and the electrification component will assess this in detail – **PROXIMITY ACCESS** are the areas (adjacent to the town infrastructures) – i.e. the Informal and PSA (Progressive Settlement Areas) Settlements –

ACCESS is defined, where the grid is within 80m of the LV network and the Lüderitz Town Council standard connection policy is applicable.

Based on the zoned approach a total of approximately 2000 -3000 informal stands needs to be electrified in Lüderitz – These are zones as per enclosed map – including current and future designated PSA (Progressive Settlement Areas).

The S-curve load growth-based HES (Household Energy Survey) is assumed to reach saturation very fast as adequate revenue (N$ 1000.- per household per month) is available. – the disposable income will be

[11] Presentation – august 2009 / GSFA/? LTC

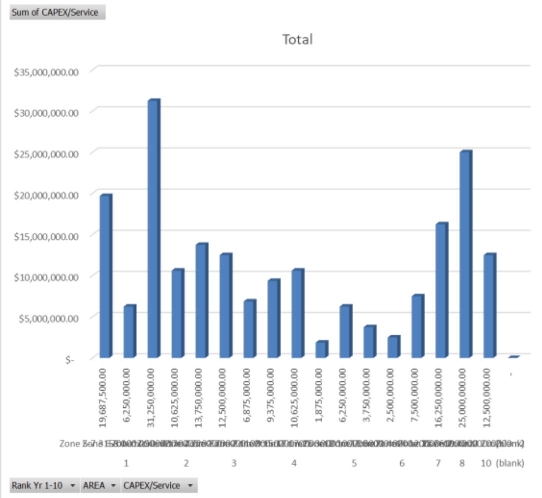
[12] 2005 MME (Ministry of Mines and Energy) Rural Electrification Masterplan

used partly for electric appliances, and approximately 50% of the energy cost will be channeled to electricity – For the economic analysis, it is predicted that N$ 90.- per month is allocated to electricity purchases to offset the other energy costs for LPG, candles etc. –

PSA identified for electrification over the next 10 years, referring to Figure 46: PSA (Progressive Settlement Areas) electrification areas.

Figure 48 : Required electrification project summary – ALL AREAS

Row Labels		Sum of CAPEX/Ser
⊟ 1	**$**	**57,187,500**
⊟ Zone 5-7 315 000m2	**$**	**19,687,500**
19,687,500.00	$	19,687,500
⊟ Zone 6-8 100 000 m2	**$**	**6,250,000**
6,250,000.00	$	6,250,000
⊟ Zone17 500000m2	**$**	**31,250,000**
31,250,000.00	$	31,250,000
⊟ 2	**$**	**24,375,000**
⊟ Zone 3 170000m2	**$**	**10,625,000**
10,625,000.00	$	10,625,000
⊟ Zone 4 220000m2	**$**	**13,750,000**
13,750,000.00	$	13,750,000
⊟ 3	**$**	**19,375,000**
⊟ Zone 1 200000m2	**$**	**12,500,000**
12,500,000.00	$	12,500,000
⊟ Zone 2 110000m2	**$**	**6,875,000**
6,875,000.00	$	6,875,000
⊟ 4	**$**	**21,875,000**
⊟ Zone 9 150000m2	**$**	**9,375,000**
9,375,000.00	$	9,375,000
⊟ Zone12 170000m2	**$**	**10,625,000**
10,625,000.00	$	10,625,000
⊟ Zone15 30000m2	**$**	**1,875,000**
1,875,000.00	$	1,875,000
⊟ 5	**$**	**10,000,000**
⊟ Zone10 100000m2	**$**	**6,250,000**
6,250,000.00	$	6,250,000
⊟ Zone13 60000m2	**$**	**3,750,000**
3,750,000.00	$	3,750,000
⊟ 6	**$**	**10,000,000**
⊟ Zone11 40000m2	**$**	**2,500,000**
2,500,000.00	$	2,500,000
⊟ Zone14 120000m2	**$**	**7,500,000**
7,500,000.00	$	7,500,000
⊟ 7	**$**	**16,250,000**
⊟ Zone 18 260000m2	**$**	**16,250,000**
16,250,000.00	$	16,250,000
⊟ 8	**$**	**25,000,000**
⊟ Zone19 400000m2	**$**	**25,000,000**
25,000,000.00	$	25,000,000
⊟ 10	**$**	**12,500,000**
⊟ Zone20 200000m2	**$**	**12,500,000**
12,500,000.00	$	12,500,000
⊟ (blank)	**$**	
⊟ (blank)	**$**	
-	$	
Grand Total	**$**	**196,562,500**



The assessment is based on:

avg. size area m2	800
Plots/units 50k/unit	0
cost/unit	$ 50,000.00

Financial and Economic Section and Overview

CHAPTER SUMMARY:

Financial and Economic Section and Overview

The asset value (based on NENA 2022) is N$ 27,000,000.-

The replacement value is N$ 81,000,000.-

The revenue (annual) in the town of Lüderitz is (estimated as indicated) N$ 100,000,000.- p.a. – with a customer base of approximately 4000 clients.

Financial assumptions are listed, and a flexible financial model presents a tool to recalculate as input variables change –

A capital appropriation proposal is submitted, recommending allocation for baseline electrification (40), Backbone infrastructure (30%), informal settlement electrification (10%), efficiency and effectiveness (15%) and support at (5%).

Three scenarios for an economic evaluation are presented – with different ratios of grant funding – varying from fully grant funded, 40% grant funded and not at all funded –

On infrastructure projects – a total investment of CAPEX BACKBONE -N$ 200,000,000 is required over the next ten years, with 57 identified projects, rank in order of priority.

On Electrification projects (irrespective of NPV) 4000 stands can be electrified at a cost of N$ 200 million, for services.

10 Financial aspect of the master plan

10.1 General

This section of the report deals with the financial and related aspects of the Master plan.

The financial discussion differentiates between three broad themes:

1. General financial assumptions and discussion
2. General financial analysis for a locality
3. Specific financial analysis for a locality

10.2 General Financial Assumptions and Discussion

10.2.1 Network Asset Summary for Lüdertiz

An asset valuation project was performed based on the survey of the assets.

NENA ID	Asset Information (ID; Net ID, Description)	Asset Type	Locality	Replacement Cost	Book Value	Life Left
		Luderitz	SUBTOTAL	81,423,818	27,681,405	34%
		REPORT	TOTAL	81,423,818	27,681,405	34%

10.3 Projects categorization

During the project design, it became clear that there are projects that must be done to sustain the existing infrastructure. These projects are different to the projects that are to be done to provide electrification electricity to new clients. It is therefore differentiated throughout this document between:

- Infrastructure projects – those that must be done.
- Development projects – those that should be done on merit.

For the Infrastructure projects no feasibility calculations are performed, as they are not linked to a specific income. The rationale is that if these projects are not done, over time the existing baseline income will be at risk.

The Development projects are the ones that should be done to expand the customer base and increase electrification. For each development project, a feasibility calculation is performed. Since there are various funding possibilities, three scenarios are provided in this document, but others can easily be simulated with the model.

10.4 Capital appropriation

In the past years Lüderitz Town Council should spent some N$ 16 million per annum on capital projects (Electrical). Considering the cash-flow from the audited financial statements, approximately N$10 million of cash-flow is available for investing. [13]

This amount is very low given the asset base and area that Lüderitz Town Council is covering but is also a result of regulation and the structure that exists between the RED and the local authorities.

For the purposes of this project, the Asset Related Revenue Requirement for Lüderitz Town Council as per the 2024/2025 ORM is expressed as percentage of the Total Revenue Requirement tbd.

[13] ORM (Operating and Reporting Manual) / ECB

10.5 Recovering of Capital expenditure through tariffs

At this point it also must be pointed out that the ECB tariff determination process allows for the recovery of network investments through electricity tariffs.

This is allowed for in the Operations and Reporting Manual Spreadsheet through Depreciation, as well as Return on Assets.

At a workshop in July 2009, a new concept of reconciliation via over- or under-recovery was introduced. This allows REDs to equalize previous years' over or under recovery through tariffs in the ensuing years.

For the purposes of this Masterplan, it is important to make capital investments when they are necessary, as it can and will be recovered through tariffs. (Refer Scenario 3) where the financed portion can be recovered via the tariffs!

10.6 Development Projects

Development projects - For every locality, there is a total list of identified projects. The projects that are relevant to this Masterplan are filtered out as follows:

1. The projects categorized as Demand Density with the codes R3, R4 are filtered out.
2. As next filter, only the projects that are less than or equal to 50% electrified are filtered out.
3. And lastly only the projects that have a Net Present Value of higher than zero Namibian Dollar are filtered out. [14]

- In short:
- Filter 1 = R3, R4
- Filter 2 = Electrification ≤50%
- Filter 3 = NPV>0

10.7 Key figures used for Development Projects

The key figures used to categorize projects are summarized in the table below:

LoadGroups and Attributes for Load and Area planning														
	Scheme		Group-Zoning	Order-Space Utilization	Special	Attribute on Income [2024 reference] / Activity	Density Factor	Avg. Erf size	Demand	Service and Electrification cost / unit	Technology recommend for infrastructure	Energy/Revenue per month		Energy Density
			Zoning	General description		estimated income per household -	2 / High Inc. = .5	[m2]	[kVA]	Development		kWHr	N$	KVA/Ha
1	1	R1	Residential	High Income		>N$45,000	0.8	1000	2.5	$ 50,000.00	Ugnd/MV.LV	600	$ 1,500.00	20
2	2	R2	Residential	Medium Income		N$30,000-N$45,000	0.6	800	1.4	$ 37,500.00	Ugnd/MV.LV	250	$ 1,000.00	11
3	4	R3	Residential	Low Income		N$15,000-N$30,000	0.3	500	0.9	$ 17,500.00	ABC / Ugnd.MV	150	$ 500.00	5
4	5	R4	Residential	VeryLow Income		N$3,000-N$12,000	0.2	225	0.5	$ 12,500.00	ABC/OHL MV.LV	80	$ 375.00	4
5	6	IS	Institutional	Government offices		...	0.5	5000	60	$ 1,500,000.00	Ugnd/MV.LV	n/a	#VALUE!	60
6	7	BC-L	Business/Commercial	Low Density	Shops/Offices	Lower cost (shops)	0.5	1000	10	$ 250,000.00	Ugnd/MV.LV	n/a	#VALUE!	50
7	8	BC-H	Business/Commercial	High Density	Shops/Offices	Upmarket / Industry / Shopping centre	0.5	2000	20	$ 375,000.00	Ugnd/MV.LV	n/a	#VALUE!	50
8	9	BP	Plots	Business		Mixed use	1	5000	10	$ 125,000.00	OH	n/a	#VALUE!	20
9	10	BA	Plots	Agricultural		Fishing/Poultry	1	10000	20	$ 175,000.00	OH	n/a	#VALUE!	20
10	11	IND-L	Industrial	Light		Transport /Serivice station	0.5	3000	15	$ 125,000.00	Ugnd/MV.LV	n/a	#VALUE!	25
11	12	IND-H	Industrial	Heavy		Milling / Manufacturing	0.5	4000	25	$ 175,000.00	Ugnd/MV.LV	n/a	#VALUE!	31
12	13	Z1	Future	mixed		Mixed	0.6	800	1.4	$ 37,500.00	Ugnd/MV.LV	250	$ 625.00	11

[14] Items 2 and 3 are not part of the ToR but are listed as options for implementation later.

The monthly energy revenue that can be expected from the respective categories has been taken into the financial model.

10.8 Funding for projects

Funding for projects can come from various sources. The very lucrative projects that are part of the lists of projects for the localities but not part of the scope of this Masterplan are likely to be funded by private investment.

The remaining projects will have to be prioritized on merit. This can include socio-economic aspects, political aspects, or other non-financial and possibly non-quantifiable considerations.

For the purposes of this Masterplan, the projects are ranked according to the Net Present Value considering three different scenarios.

Scenario 1 provides for 100% Grant funding. It is important to note that the 100% Grant funded projects are feasible and are indeed sustainable. Whether these funds come from Donor Agencies, or the Government is not relevant.

Scenario 2 provides for 0% Grant funding. In this scenario the projects that are truly feasible and self-sufficient are identified. These projects should be done as quickly as financially possible. In this scenario a typical commercial bank loan facility for 60% of the total investment is included in the calculation. This means that 40% of the total investment needs to come from our own resources.

Scenario 3 provides for the same commercial funding as scenario 2, except that 40% is Grant funded. In the current world economic situation, it is considered easier to obtain 40% for several projects, rather than to obtain 100% for few. This reduces the absolute investment amount per project for a Donor, and spreads electrification faster, which is in the interest of the Government of Namibia.

The financial analysis is beyond the scope of the project – Scenario 1 is assessed only.

11 General financial analysis for Lüderitz

11.1 Capital Appropriation - Lüderitz

Capital appropriation requires a long-term strategic view to ensure a balanced and sustainable investment plan.

As a guideline, the available annual spend should be categorized in the types of investment that are necessary for the business.

The main investment categories are as depicted below:

11.1.1 Baseline (50%)

New urban connections and service provisioning. Includes social obligation projects.

11.1.2 Backbone / Capacity upgrade (15%)

Ensures sound platform for future service delivery, long term survival, driven by long term strategic goals.

11.1.3 PSA (low cost) Electrification (15%)

Typically, not profitable

11.1.4 Efficiency and effectiveness (15%)

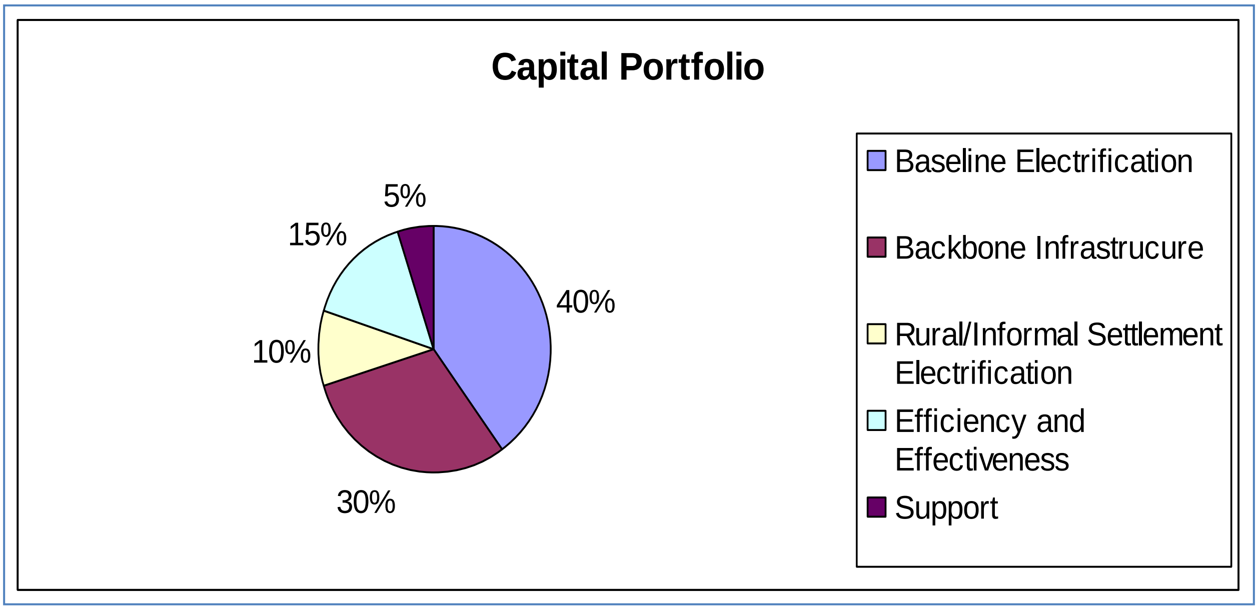
improves the business’s financial returns through cost savings or revenue enhancements (e.g. AMR)

11.1.5 Support (5%)

required to remain in a "steady state" not likely to expand proportionally to the size of the portfolio (non-network capital) (e.g. IT)

Segmenting the total budget ensures long-term balance in business focus.

Figure 49 :Masterplan proposed Capital Portfolio



[15]

From the Capital Appropriation model, it is suggested that 40% of the annual capital investment is invested in baseline projects. This investment is considered non-discretionary since the baseline projects include new connections and service provisioning and are essentially the bread-and-butter line of projects for any business.

A further 30% of the available budget should go to Backbone infrastructure. This ensures a sound platform for future service delivery and should be driven by long-term strategic goals.

The remaining 30% are considered discretionary spending. Discretionary spending in this instance does not refer to whether to spend it or not, but rather how to spend it.

Electrification and Informal Settlement Electrification is part of the fulfillment of socio-economic up-liftmen and is relevant and important to Namibia. The spending on these projects should be approximately 10%. These projects typically should be done with Grant Aid funding.

The effective and efficient management of the business often requires capital investment. This typically includes Automated Meter Reading (AMR) systems, Demand.

Side Management (DSM), Meter Audits and other management tools. As a guideline, an average of 15% per annum should be reserved for such projects.

Another category that should be considered is projects that can be considered as Support. Support projects typically include Information Technology (IT) projects. The differentiation to the projects in the Efficiency and effectiveness category lies in that Support projects are not directly related to revenue generating infrastructure and should be limited to 5% of the annual total capital budget.

It is therefore imperative to obtain Grant Aid funding for the envisaged projects.

[15] Source – CBC / NORED PCE master plan.

11.2 Infrastructure Projects - Lüderitz

Figure 50 :CAPEX projects: LÜDERITZ ()

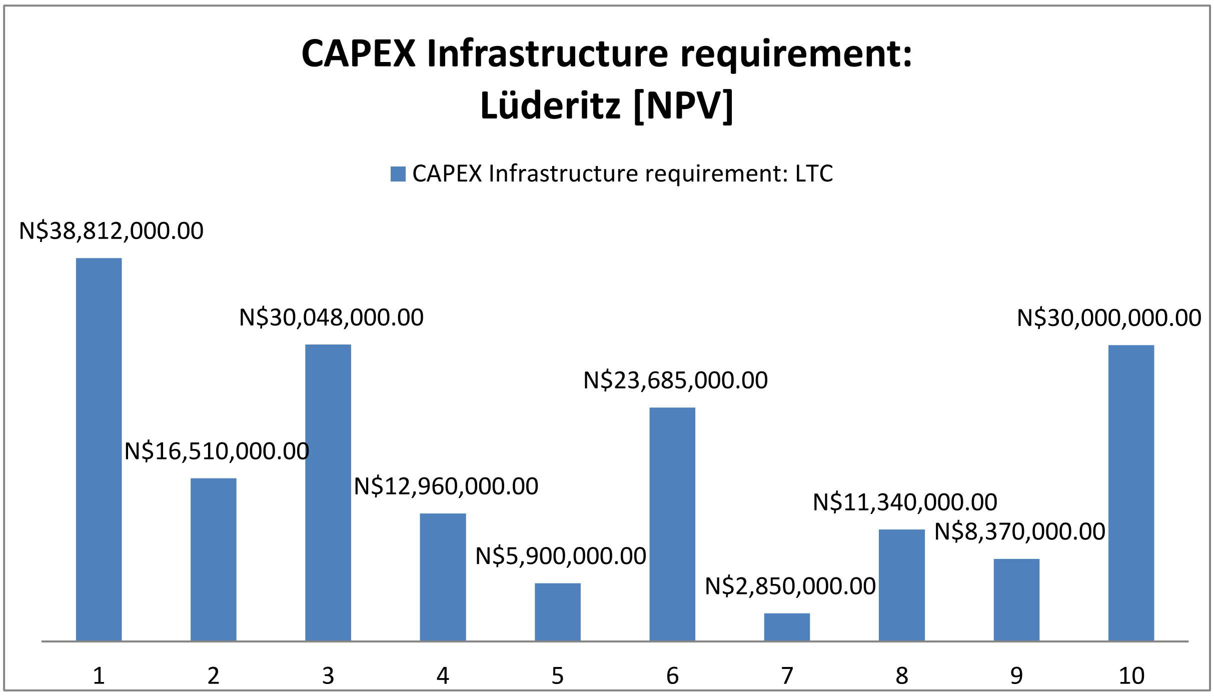


Figure 51 :CAPEX for infrastructure projects: LÜDERITZ.

A total investment of N$180[16] million is expected over the next ten years. These projects are essential to be done, to sustain the current network usage over time.

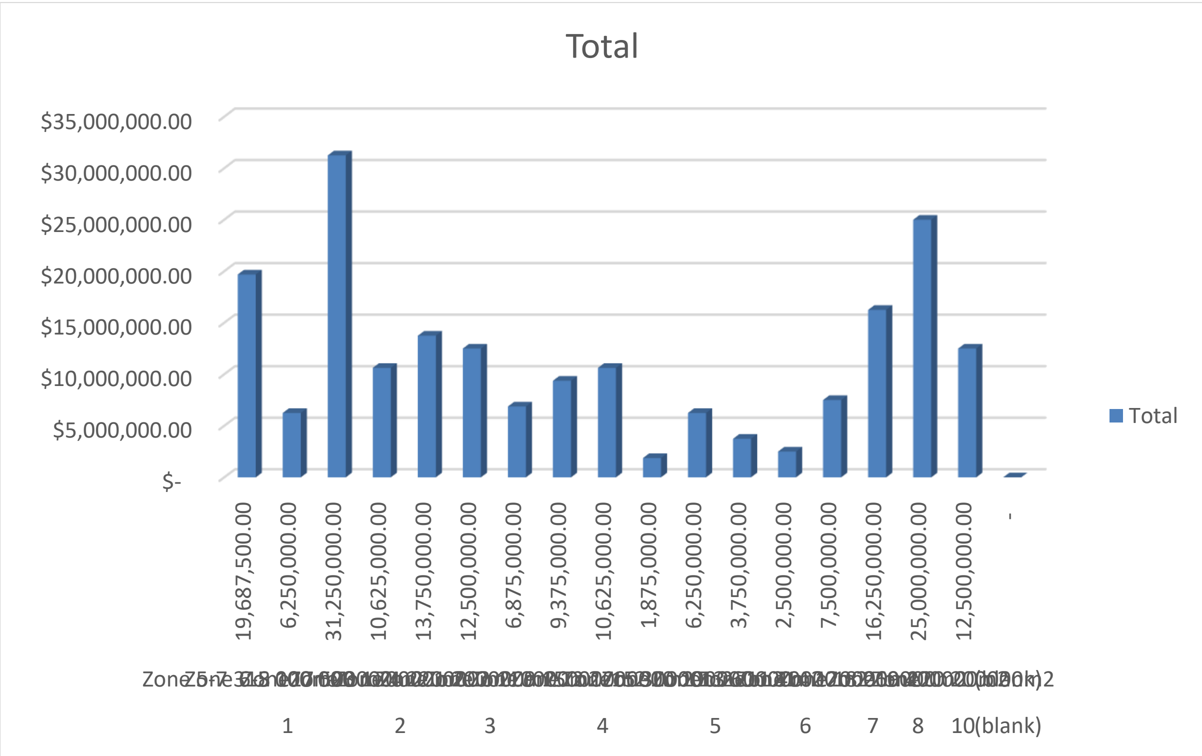


Figure 52: Electrical Services- 10-year period.

[16] [16] Values not adjusted for future inflation.

Appendices

12 Appendices

12.1 DRAWINGS - Drawing List –

Drawing No.					General description
MV	Comment	ACAD	Qty	PDF	
LTC-MV-2025	Each node numbered	A1	1	A4	current as-built MV
LTC-MV-FUTURE	*Each node numbered - planned network*	A1	1	A4	indicate future expansion - incl. cable size, distance, cost estimate = Future system (2020) - all project required (circled as upgrade) - these projects for info the INFRASTRUCTUR DEVELOPEMNT PLAN, AND ARE LISTED in the SPREADSHEET
LTC-MV-01 …10	FlipFile	A3	10	A4	based on as-built, a block layout for each area - numbered 1 …. N
LTC-MV-SLD-2025		A1	1	A4	current as-built SLD - for Load-flow study
LTC-MV-SLD-FUTURE	Future planned network	A1	1	A4	Future system (2020) - all project required (circled as upgrade) - these projects for info the INFRASTRUCTUR DEVELOPEMNT PLAN, AND ARE LISTED in the SPREADSHEET
LTC-MV-DS+SS-1.5	Intake and Dist.Stations	A4		A4	Schematics
LV					
LTC-LV-01…24	FlipFile	A3	24	A4	based on as-built, a block layout for each area - numbered 1 …. N
LTC-LV-PSA01(A)	Electrification plan re. LZ dwg.				refer to LTC-LZ - each area R3 and R4 will get a concept design for electrification
Planning					
LTC-LZ	LoadZones: Colour Area per Zone, referenced	A3	1	A4	Colour map for Load planning - and PSA (Progressive Settlement Areas) electrification planning
LTC-LN+PF	LoadNodes and PowerFlow	A3	1	A4	Planned Loadgrowth, indicating circles for 2025 - 2015-2020 load growth in different strategic area
LTC-LC	Load Circles - 500m & 1000m Radius	A3	1	A4	Load planning re. distribution nodes - radius of 500m. 1000m 1500m - to see how far we distribute from a node
LTC-GE-TOWN	Erf and MV overlay on GoogelEarth - Town Centre	A4	1	A4	Overlay of erven and MV infrastructure on Googel Earth bitmap - for reference purposes and document printing procedures.

12.2 Load Research – Herman Beta design coefficients

12.2.1 Guidelines towards Herman Beta parameters for the Namibian context

Initial guidelines are presented for appropriate Herman Beta parameters in this section.

These guidelines are derived from the following:

- The established relationship between demand and consumption is witnessed in 76 case studies assembled.
- The similarity in the demand/consumption behaviour of SA and Namibian consumers
- An established relationship between dispersion of households at the peak and the consumption, fitted with South African data only.

Notes:

- No guidelines are provided on factors affecting consumption level or consumption growth in a particular area.
- The levels of risk or confidence employed by electricity suppliers are not factored in. Factors presented here represent average behaviour of the consumer groups studied.
- It is assumed that the designer never chooses a circuit breaker size, which materially affects load characteristics of the consumer.

Initial guidelines based upon the qualifications above are shown in Figure 53.

Figure 53: Initial Herman beta guidelines (Cb = 80A)

Consumption level (kWh/hh/month)	Est. ADMD (kVa)	I ave (A)	Istdev (A)	Alpha	Beta
100.00	0.53	2.30	3.28	0.45	15.13
200.00	0.88	3.80	4.64	0.59	11.86
300.00	1.23	5.31	5.69	0.75	10.52
400.00	1.58	6.81	6.56	0.90	9.67
500.00	1.93	8.32	7.34	1.05	9.02
600.00	2.28	9.82	8.04	1.19	8.48
700.00	2.63	11.33	8.68	1.32	8.00
800.00	2.98	12.83	9.28	1.44	7.56
900.00	3.33	14.34	9.85	1.56	7.15
1,000.00	3.68	15.84	10.38	1.67	6.76
1,100.00	4.03	17.35	10.89	1.77	6.40
1,200.00	4.38	18.85	11.37	1.87	6.05

Guidelines are presented upon the basis that 80A circuit breaker limiting is in use.

Re-casting according to the deterministic formula is required for other circuit breaker sizes.

12.3 Project Cost components –

Figure 54 : Network cost components.

Cost Estimates for Infrastructure Capital Projects						
MV_Overhead lines	**CODE_Range**			cost/km		total/m
Gopher: 11/22/33kV -	OH_G	150	A	N$ 320,000.00		N$ 320.00
Rabbit: 11/22/33kV -	OH_R	240	A	N$ 400,000.00		N$ 400.00
Hare: 11/22/33kV -	OH_H	360	A	N$ 480,000.00		N$ 480.00
70Cu 7/3.35mm2 : 11/22/33kV -	OH_70Cu	360	A	N$ 480,000.00		N$ 480.00
90 Cu 7/2.25mm2 : 11/22/33kV -	OH_90Cu	440	A	N$ 720,000.00		N$ 720.00
MV_Cables (installed)				cost/m	cost/m	total/m
70mm2 Cu XLPE TypeA	70XLPE	240	A	N$ 1,400.00	N$ 500.00	N$ 1,900.00
95mm2 Cu XLPE TypeA	95XLPE	290	A	N$ 1,760.00	N$ 500.00	N$ 2,260.00
120mm2 Cu XLPE TypeA	120XLPE	325	A	N$ 2,000.00	N$ 500.00	N$ 2,500.00
150mm2 Cu XLPE TypeA	150XLPE	360	A	N$ 2,200.00	N$ 500.00	N$ 2,700.00
185mm2 Cu XLPE TypeA	185XLPE	410	A	N$ 2,640.00	N$ 500.00	N$ 3,140.00
ABC all incl. poles+S/L						total/m
70mmAl 3P+N+S/L	70ABC	200	A	N$ 400.00	N$ 100.00	N$ 500.00
Trafo+MB+DB				cost/unit	instal.	total/unit
50kVA	50_TX			N$ 240,000.00	N$ 10,000.00	N$ 250,000.00
100kVA	100_TX			N$ 320,000.00	N$ 10,000.00	N$ 330,000.00
200kVA	200_TX			N$ 400,000.00	N$ 10,000.00	N$ 410,000.00
Minisub				cost/unit	instal.	total/unit
200kVA	200_MS			N$ 1,000,000.00	N$ 50,000.00	N$ 1,050,000.00
315kVA	315_MS			N$ 1,080,000.00	N$ 50,000.00	N$ 1,130,000.00
500kVA	500_MS			N$ 1,200,000.00	N$ 50,000.00	N$ 1,250,000.00
Switching station				cost/unit	instal.	total/unit
Building	DS_BLDG			N$ 1,200,000.00	N$ 50,000.00	N$ 1,250,000.00
Switch (C/B complete)	DS_CB			N$ 1,600,000.00	N$ 50,000.00	N$ 1,650,000.00
RMU				**cost/unit**	**instal.**	**total/unit**
3Way Fused	3_RMU			N$ 400,000.00	N$ 30,000.00	N$ 430,000.00
4Way fused	4_RMU			N$ 480,000.00	N$ 30,000.00	N$ 510,000.00
4-way switches	4S_RMU			N$ 600,000.00	N$ 30,000.00	N$ 630,000.00
Switches _ OH Lines				**cost/unit**	**instal.**	**total/unit**
McWade Switches	SW_L			N$ 60,000.00	N$ 5,000.00	N$ 65,000.00
DoF	SW_DOF			N$ 40,000.00	N$ 5,000.00	N$ 45,000.00
LB	SW_LB			N$ 40,000.00	N$ 5,000.00	N$ 45,000.00
ARC-AutoRecloser				**cost/unit**	**instal.**	**total/unit**
NuLEC 12kV	ARC_11			N$ 520,000.00	N$ 50,000.00	N$ 570,000.00
NuLEC 36kV	ARC_33			N$ 720,000.00	N$ 50,000.00	N$ 770,000.00
S/L Streetlighting				**cost/km**	**instal.**	**total/km**
Streetlight -Main	SL_M			N$ 600,000.00	N$ 50,000.00	N$ 650,000.00
Streetlight - Minor	SL_MIN			N$ 520,000.00	N$ 50,000.00	N$ 570,000.00

12.4 Load groups and attributes or Load planning

LoadGroups and Attributes for Load and Area planning														
	Scheme		**Group-Zoning**	**Order-Space Utilization**	**Special**	**Attribute on Income** [2024 reference] **/ Activity**	**Density Factor**	**Avg. Erf size**	**Demand**	**Service and Electrification cost / unit**	**Technology recommend for infrastructure**	**Energy/Revenue per month**		**Energy Density**
			Zoning	General description		estimated income per household -	2 / High Inc. = .5	[m2]	[kVA]	Development		kWHr	N$	KVA/Ha
1	1	R1	Residential	High Income		>N$45,000	0.8	1000	2.5	$ 50,000.00	Ugnd/MV.LV	600	$ 1,500.00	20
2	2	R2	Residential	Medium Income		N$30,000-N$45,000	0.6	800	1.4	$ 37,500.00	Ugnd/MV.LV	250	$ 1,000.00	11
3	4	R3	Residential	Low Income		N$15,000-N$30,000	0.3	500	0.9	$ 17,500.00	ABC / Ugnd.MV	150	$ 500.00	5
4	5	R4	Residential	VeryLow Income		N$3,000-N$12,000	0.2	225	0.5	$ 12,500.00	ABC/OHL MV.LV	80	$ 375.00	4
5	6	IS	Institutional	Government offices		...	0.5	5000	60	$ 1,500,000.00	Ugnd/MV.LV	n/a	#VALUE!	60
6	7	BC-L	Business/Commercial	Low Density	Shops/Offices	Lower cost (shops)	0.5	1000	10	$ 250,000.00	Ugnd/MV.LV	n/a	#VALUE!	50
7	8	BC-H	Business/Commercial	High Density	Shops/Offices	Upmarket / Industry / Shopping centre	0.5	2000	20	$ 375,000.00	Ugnd/MV.LV	n/a	#VALUE!	50
8	9	BP	Plots	Business		Mixed use	1	5000	10	$ 125,000.00	OH	n/a	#VALUE!	20
9	10	BA	Plots	Agricultural		Fishing/Poultry	1	10000	20	$ 175,000.00	OH	n/a	#VALUE!	20
10	11	IND-L	Industrial	Light		Transport /Serivice station	0.5	3000	15	$ 125,000.00	Ugnd/MV.LV	n/a	#VALUE!	25
11	12	IND-H	Industrial	Heavy		Milling / Manufacturing	0.5	4000	25	$ 175,000.00	Ugnd/MV.LV	n/a	#VALUE!	31
12	13	Z1	Future	mixed		Mixed	0.6	800	1.4	$ 37,500.00	Ugnd/MV.LV	250	$ 625.00	11

12.5 Load-Flow Simulation data –

12.5.1 Simulations

12.5.1.1 Drawings

12.5.1.2 Data – Voltage Profile

12.5.1.3 Data – Short Circuit levels

12.6 Inception Meeting

12.7 QoS

SITE ASSESSMENT SUMMARY

Standard assessed against: NRS048-2:2015

For: LTC NamPower Main Intake 11kV

Period: 2024-04-01 00:00 to 2024-05-01 00:00

** Timezone: Africa/Windhoek

Site Information

Last instrument for the reporting period was Mon000002313.
Last declared voltage for the reporting period was 11000.00V which is equal to the nominal voltage of 11000.00V.

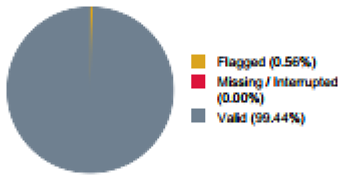
Where contractual levels are not specified for the measurement point, this report falls back to the criteria provided for by the power quality standard.

Data Availability

Paragraph 4.2.1.6 of NRS048-2:2015 considers an assessment to be valid for statistical purposes when the data available for the period is at least 90% and valid for investigational purposes when the data available is at least 98%.

- This assessment is valid for statistical purposes

- This assessment is valid for investigational purposes



reports

12.8 References

1) *MME (Ministry of Mines and Energy)*

   Rural Electrification Master-plan MME (Ministry of Mines and Energy) 2000 and as revised for 2005

2) *2024 Population and Housing Census – Regions – ad-ho input / HTTP*

3) *DiGSILENT © Simulations software / applications / handbook*

4) *Verbal discussions –*
   Inception meeting / Lüderitz Town Council / Town Planners

5) *Lüderitz Town Council NENA Asset Register 2020*

6) *LTC masterplan 2010*