Geographical Load Forecasting
- The Tutorial -

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Seminar: Domestic Electric Loads (consumption, demand & profiles)

Venue: John Maree Auditorium, Eskom Academy of Learning, Midrand

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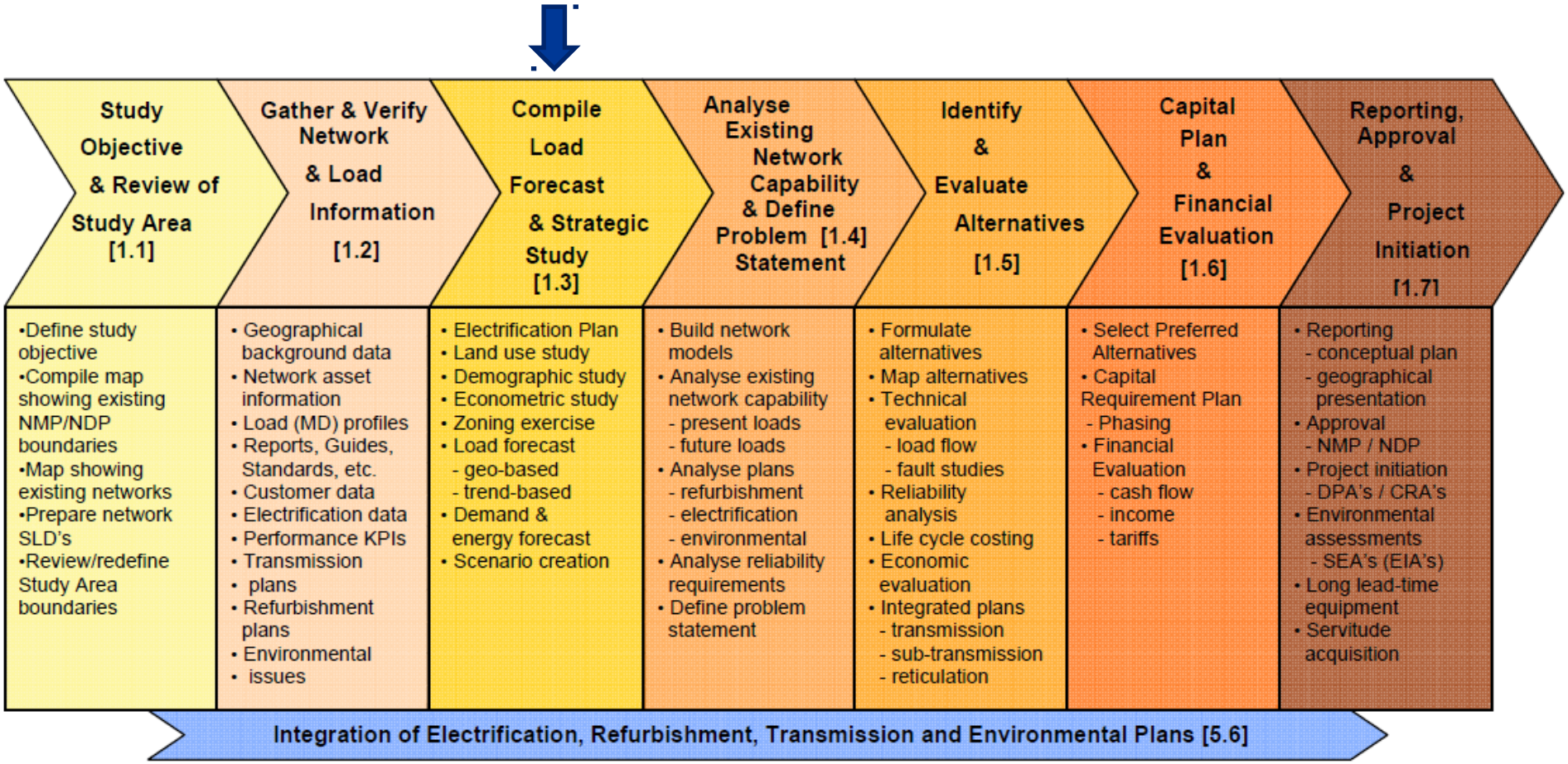
Introduction

- This tutorial demonstrates how the domestic load (consumptions, demand and profiles) is used in Eskom Distribution (Dx) Planning, to forecast the load and plan the electrical infrastructure. The presentation will deal with the following aspects:
  - Planning Process/Methodology Overview;
  - Small Area Forecast;
  - Geographical Based Load Forecast Methodology;
  - Load Subclasses;
  - Load mix for capacity planning;
  - Potential Demand Modelling;
  - Conclusion; and
  - Areas of Improvement.

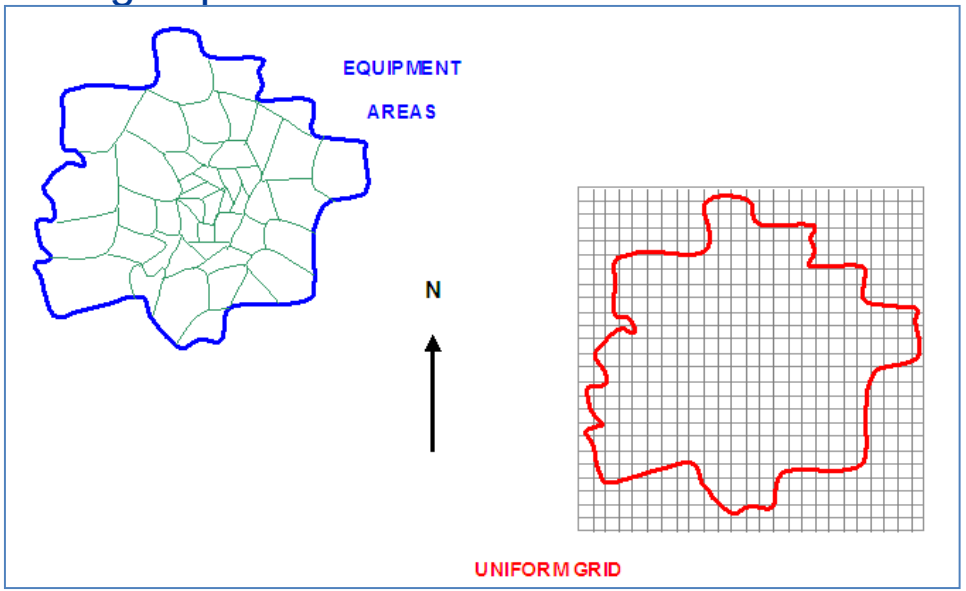
1. Background

Planning Process

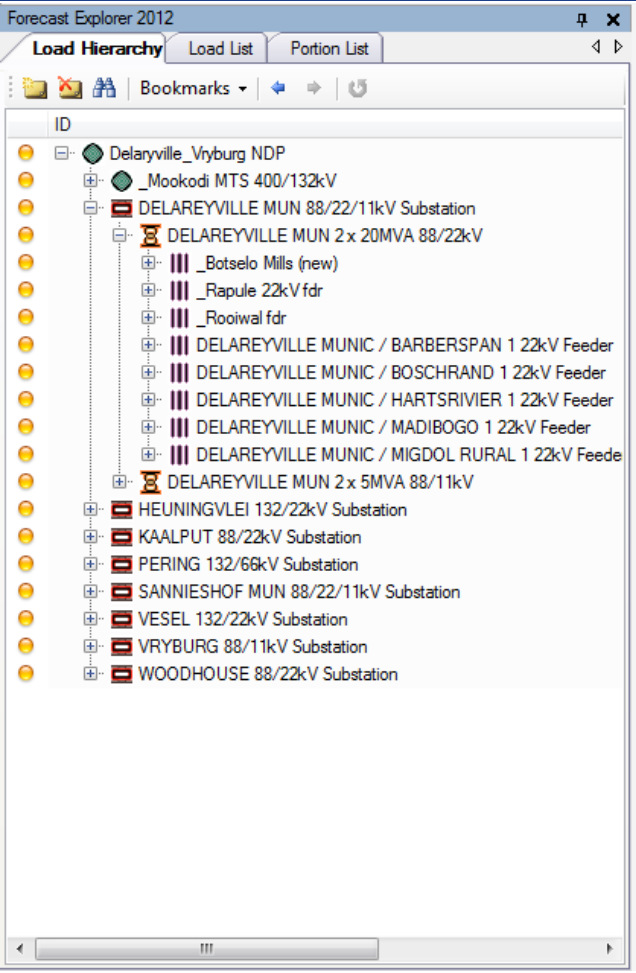


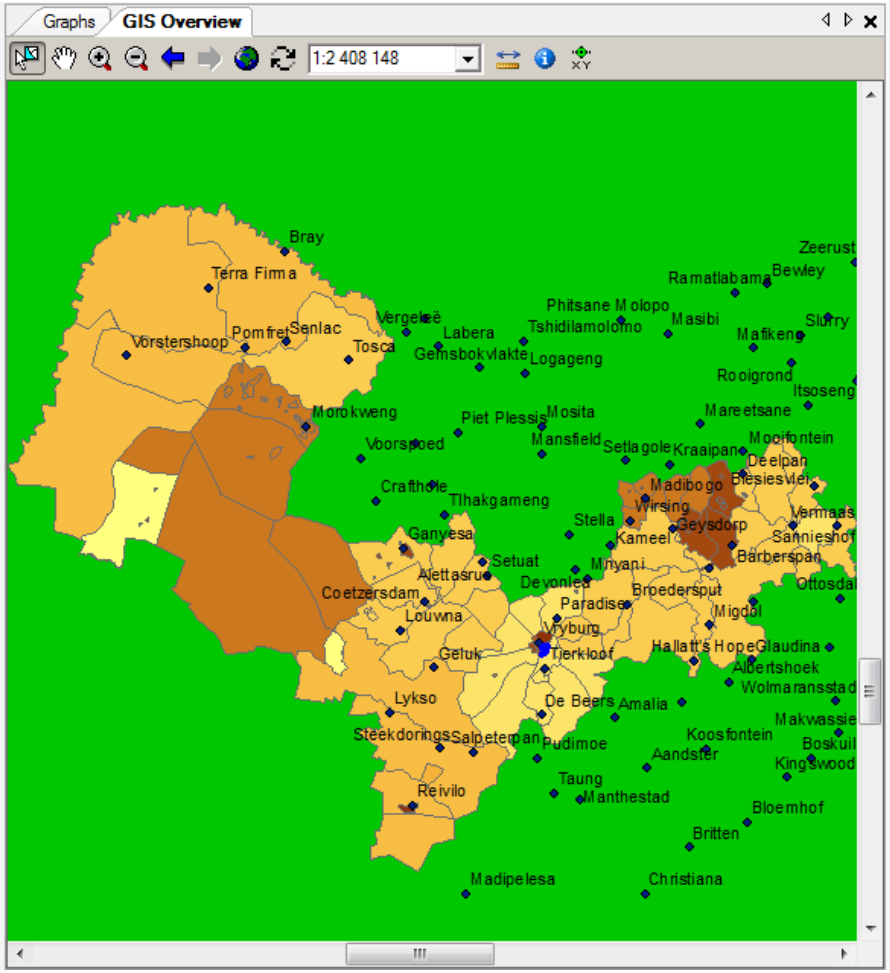
Geographical Based Load Forecast

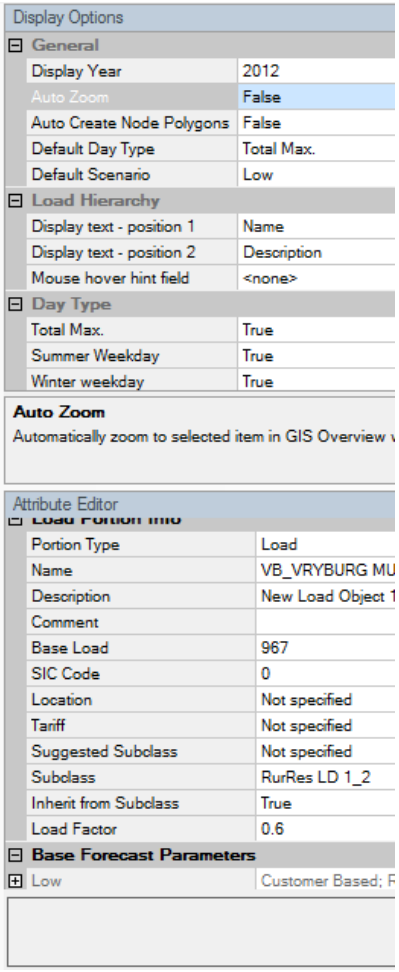
- Small Area Forecasting concept dates back to the early 1950's.
- GLF:*Geo-based load forecasting can be defined as the approach to forecast the future electrical demand by splitting the study area into smaller subdivisions on the map, followed by assignment of electrical properties to the subdivisions using the load classes, forecasting the individual subdivisions on a coordinated or non-coordinated basis, and aggregating the sum of the forecasts to cover the bigger study area. The process involves defining load classification according to the economic class and electrical demand properties.*
- The load is forecasted to show the following aspects:
  - Where,
  - When,
  - How Much, and
  - What.



PowerGLF Tool







Network (planning)

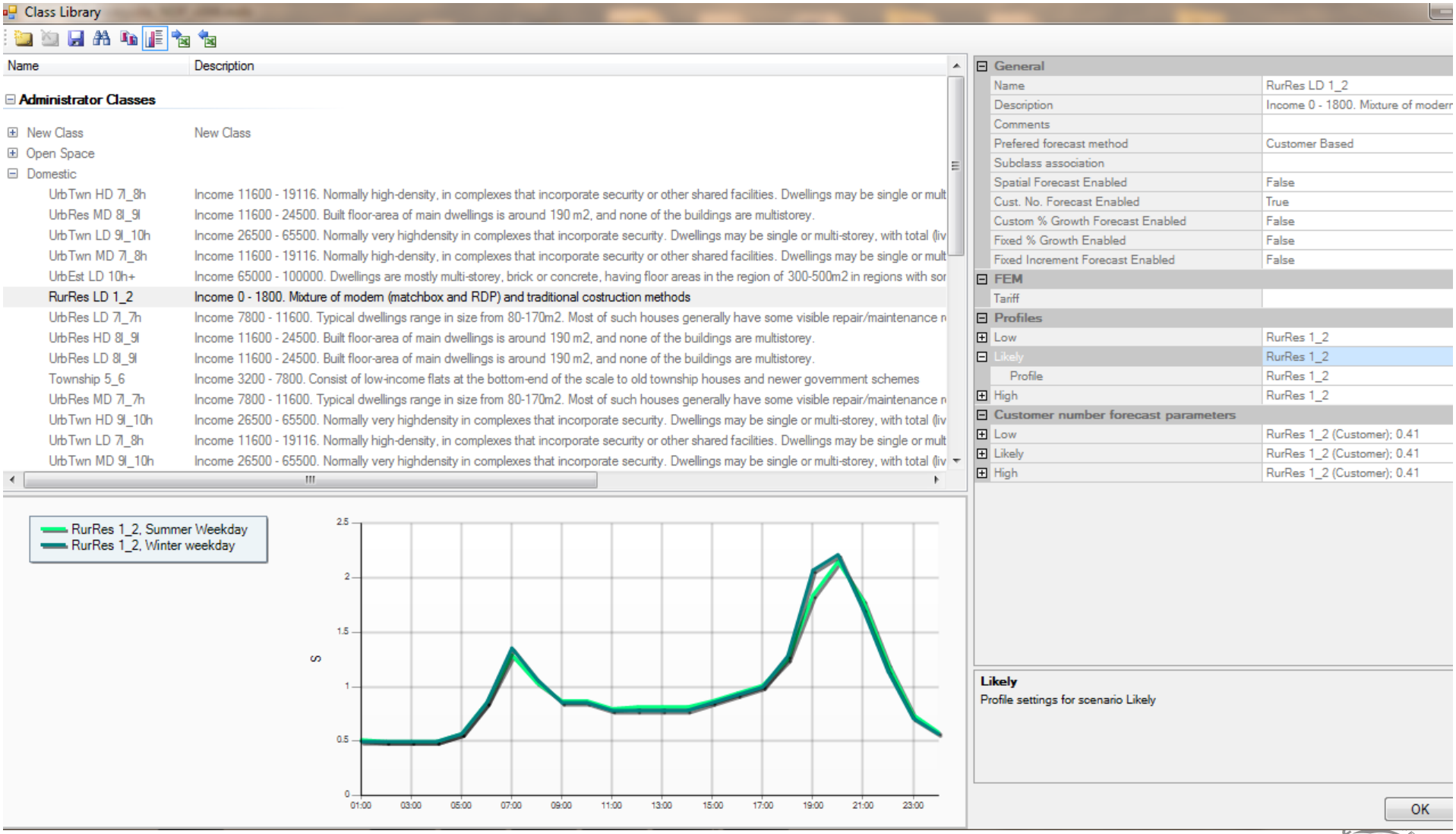
Where

What; How Much; When

Defining the subclass

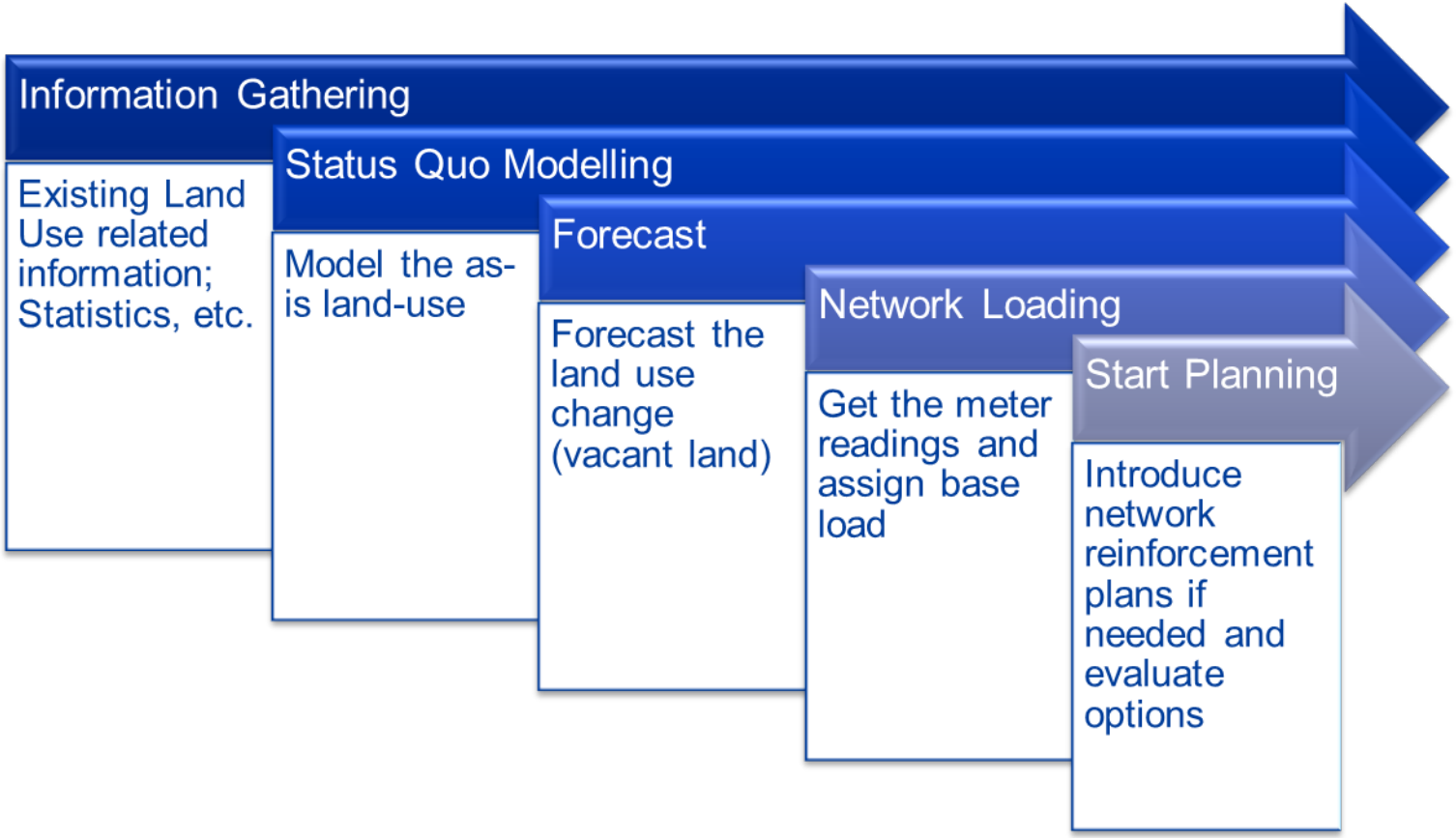
- The subclass may be defined as the load categorisation according to economic class, energy consumption characteristics and location.
- It is used as means of converting input information (to PowerGLF) into electrical terms (kVA, MW, etc).
- PowerGLF consists of a Class Library, that hosts load classes and subclasses. The library has the following attributes:
  - Load Classes
  - Subclasses
  - Economic classification
  - 24-hour consumption profile
  - Growth Curves associated with the subclass
  - ADMD (kVA and kVA/ha)

Load Subclasses Library



2. Forecasting Green Fields and Built Up Areas

GLF Forecasting Process

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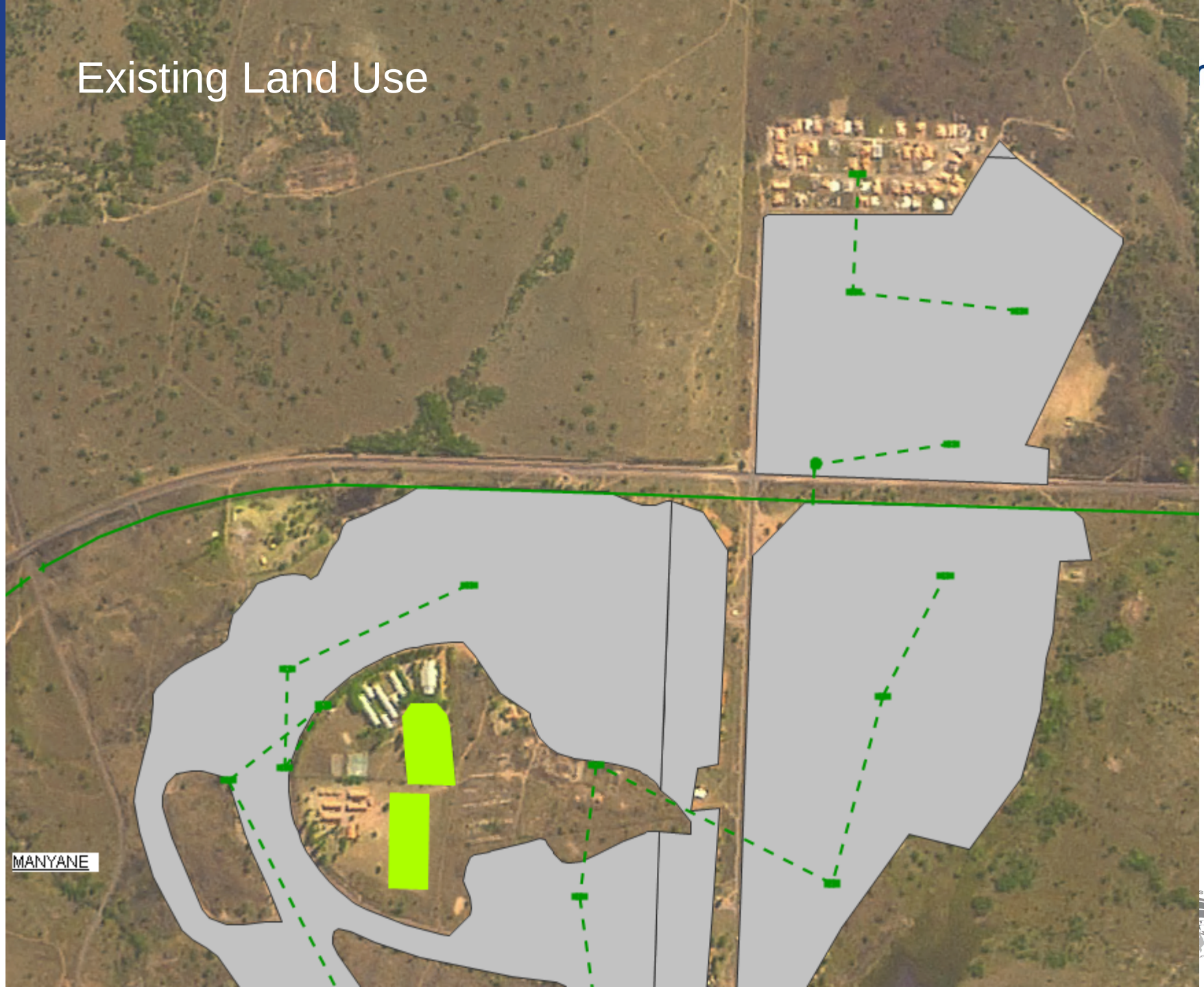
Existing Land Use



Assigning The Subclass

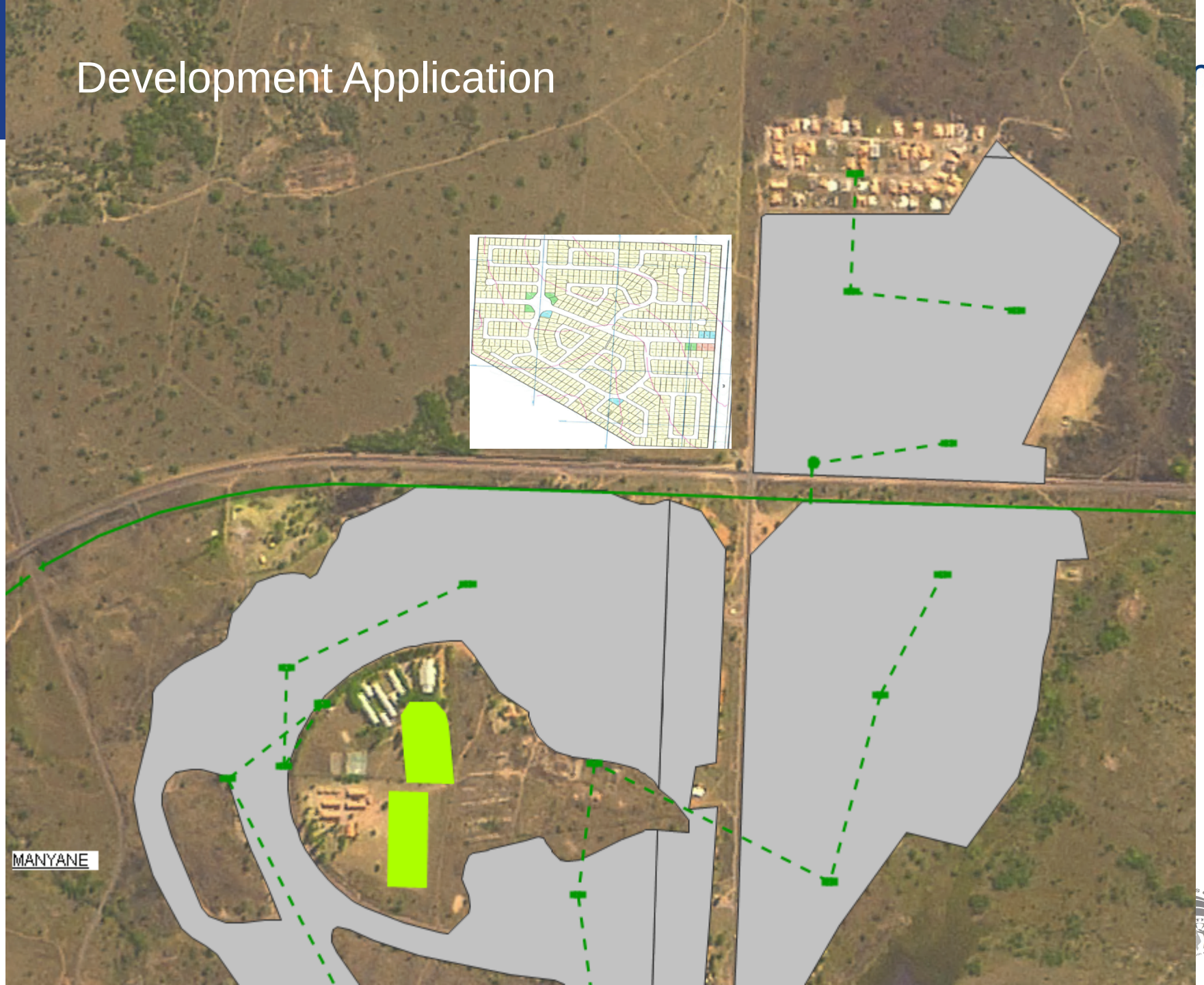
UrbRes MD 8_9

Urban residential dwellings (larger houses, "white collar"), at **medium density**.

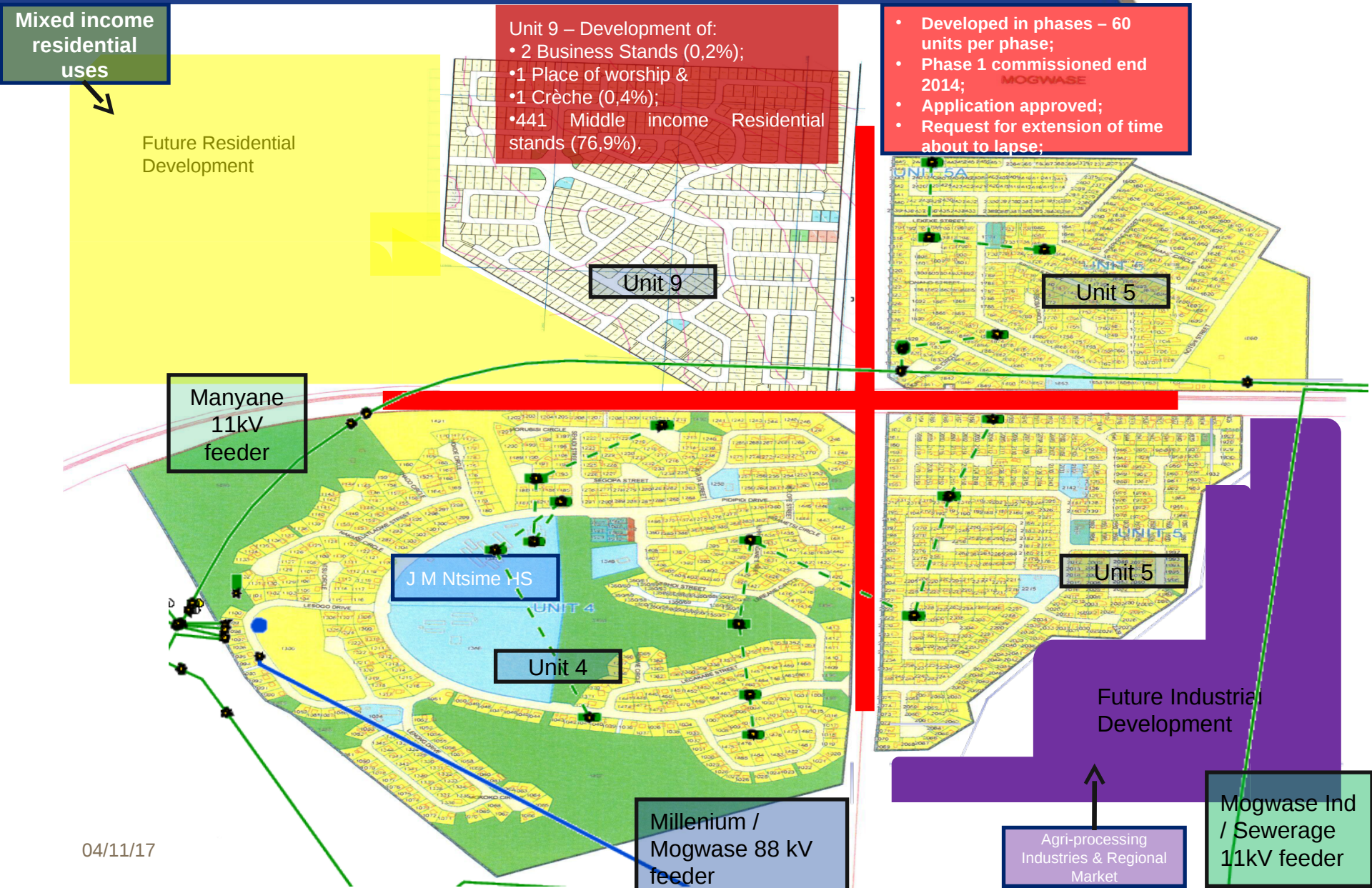
Customer Characteristics	
AMPS LSM Class	LSM 8(low) – LSM9(Low)
Income Range	11,600 to 24,500
Derivation of Income	Derived from formal employment in cities, mostly in white-collar capacity.
Description of Dwellings	Built floor-area of main dwellings is around 190 m^2, and none of the buildings are multi-storey.
Type of Roads	All tarred.
Water Reticulation	Piped water is supplied into all houses, all of which have electric hot-water geysers.

Load Characteristics				
Load Profile	Load factor = 0.41 (Year 7)			
Load Growth	**Growth-curve name**	**Curve type**	**Saturation**	
			Admd	**kWh**
	UrbRes 8_9 (customer)	Per connection	2.88	864
	UrbRes 8_9 (S-curve Prj Yrs:3)	Per Ha	50.5	
	UrbRes 8_9 (S-curve Prj Yrs:7)	Per Ha	50.5	
	UrbRes 8_9 (S-curve Prj Yrs:10)	Per Ha	50.5	

Development Application



Local Development Overview



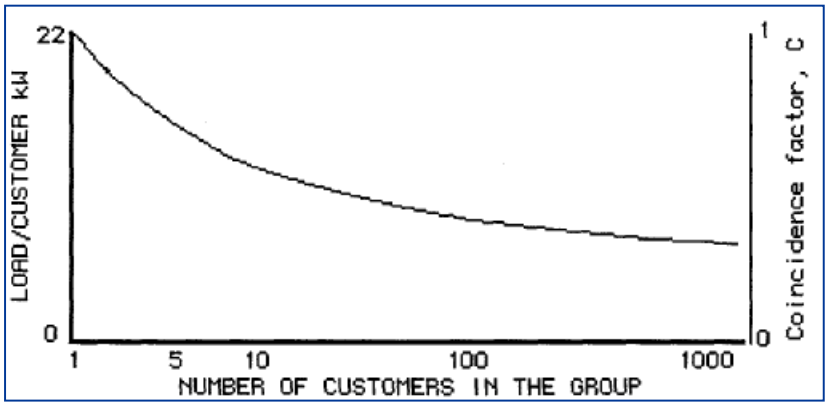
Subclass validation

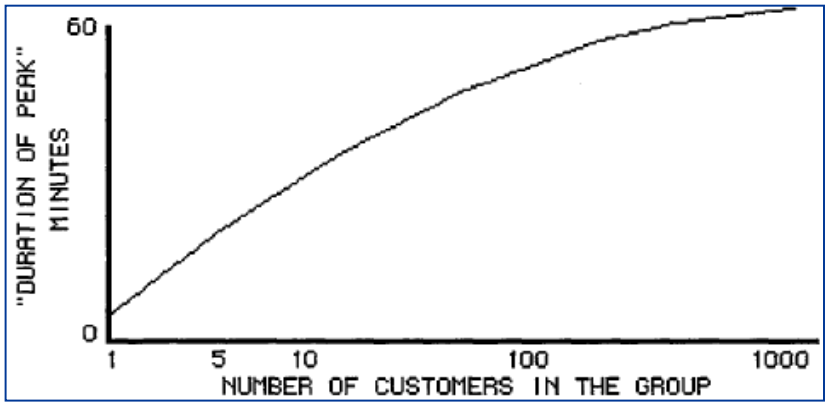
- Feeder Load (recorded) = 5.2MVA
- Built up area = 111ha
- Load density = 47kVA/ha

- One can workout the feeder load provided that the load zone (subclass) is modelled accurately and the area size is known:
  - Area = 111ha;
  - Load Density = 50.8kVA/ha (from the subclass)
  - Maximum Demand = 5.6MVA (Area*Load Density)
- Factors affecting the difference between measured and calculated MD (“Max Ratio”):
  - Losses (kW) - need to be quantified.
  - The Area (111ha) represents the built up land. At high spatial resolution, this number will be reduced.
  - Data percentile: what was applied on the stats meter vs. subclass.

Subclass validation (continued)

- Factors affecting the difference between measured and calculated MD (“Max Ratio”):
  - Ageing subclasses.
  - The ADMD is not a “fixed” value, in that, it decreases as the number of house holds increases.



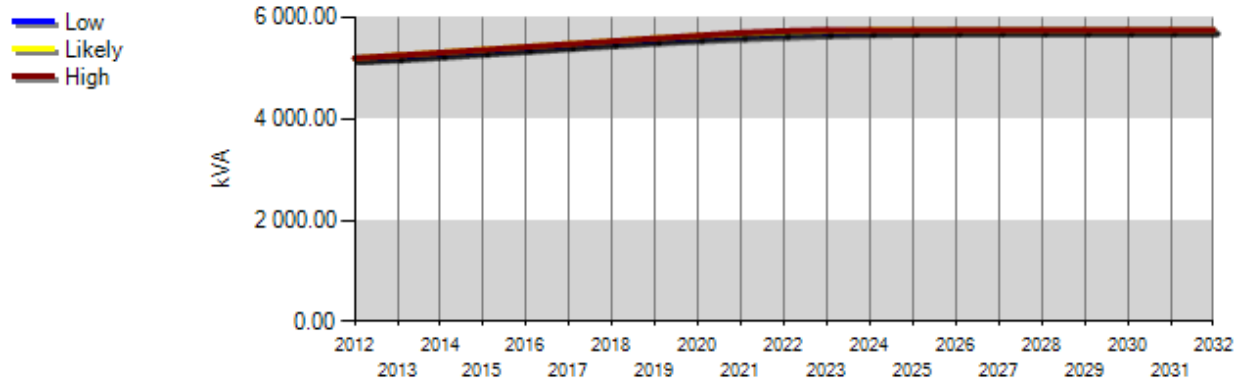


Forecast Results

The Built Up Area: Unit 4 and 5

Notes:

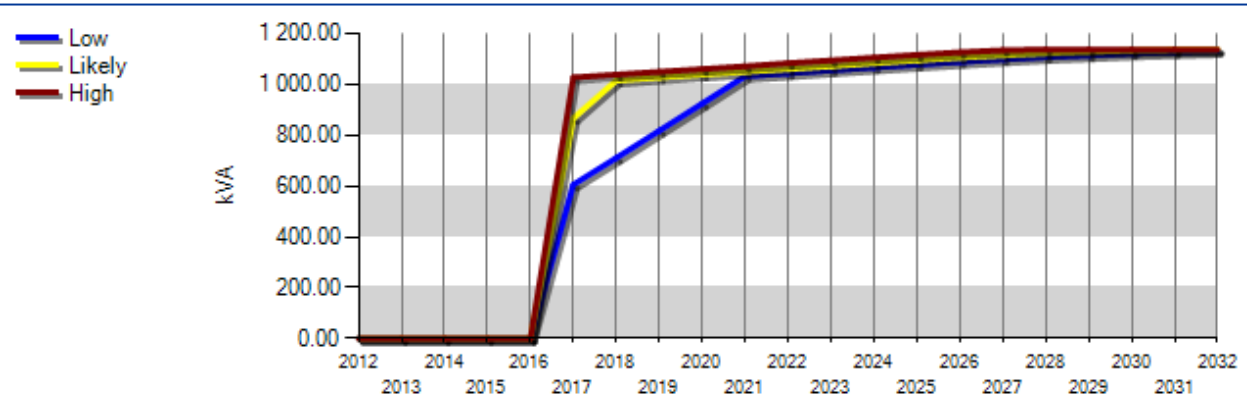
The area is built up and has been zoned for medium density and there is no further densification forecasted. The growth is based on possible increase in kW/capita



The Forecasted Area: Unit 9

Notes:

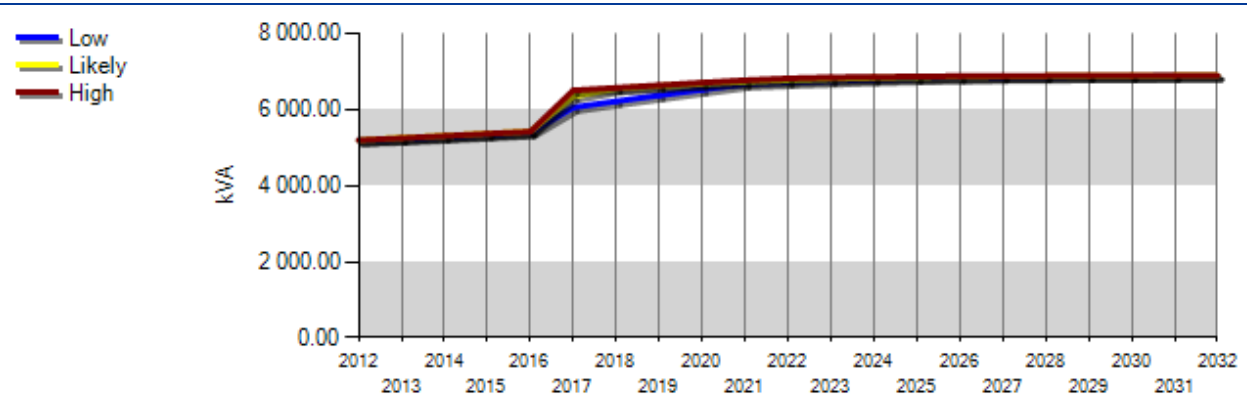
In nature, this forecasted area will be similar to the existing. The sharp growth is due to people moving in to this area.



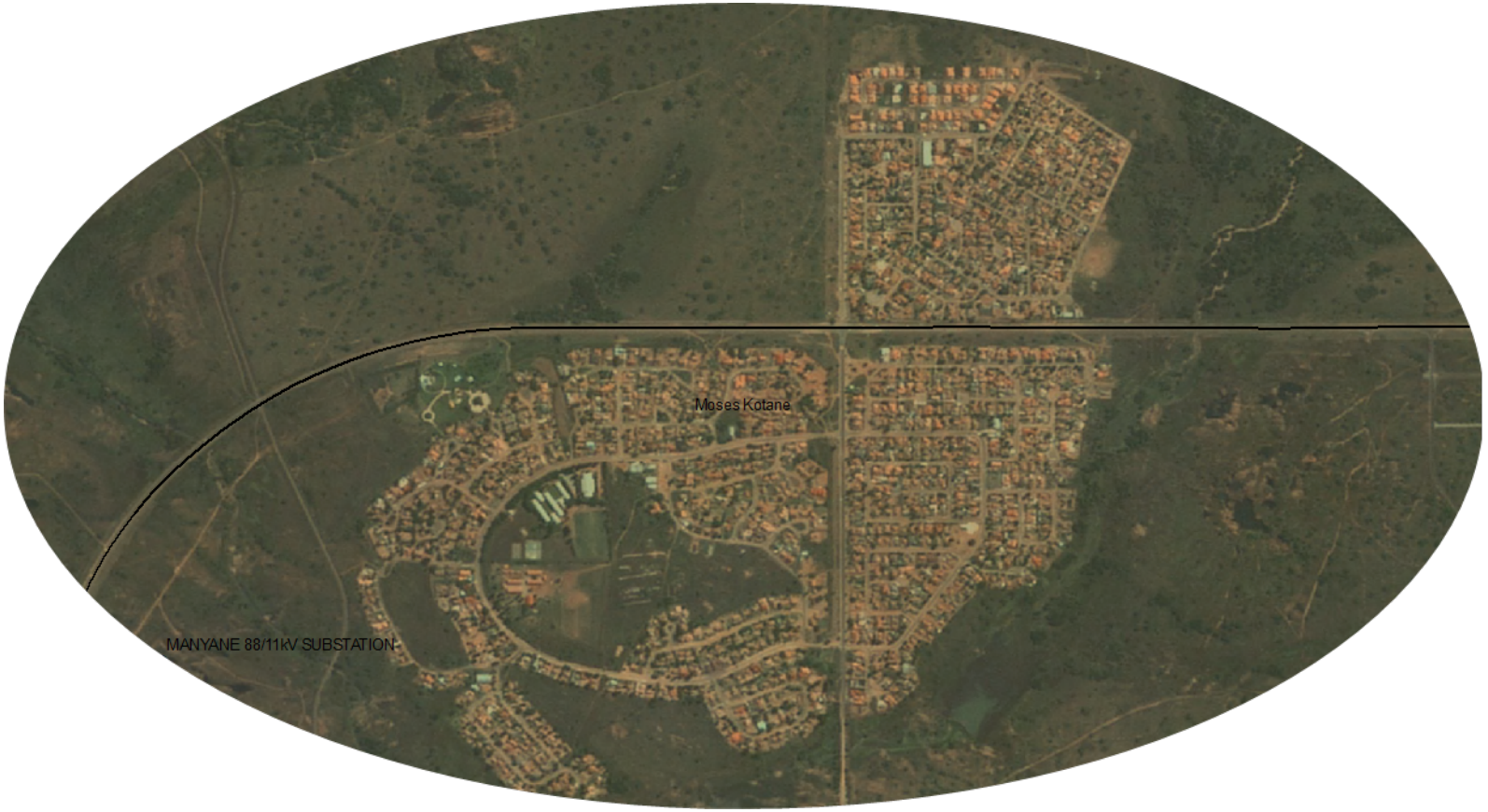
Total Feeder Area: Uni 4, 5 and 9

Notes:

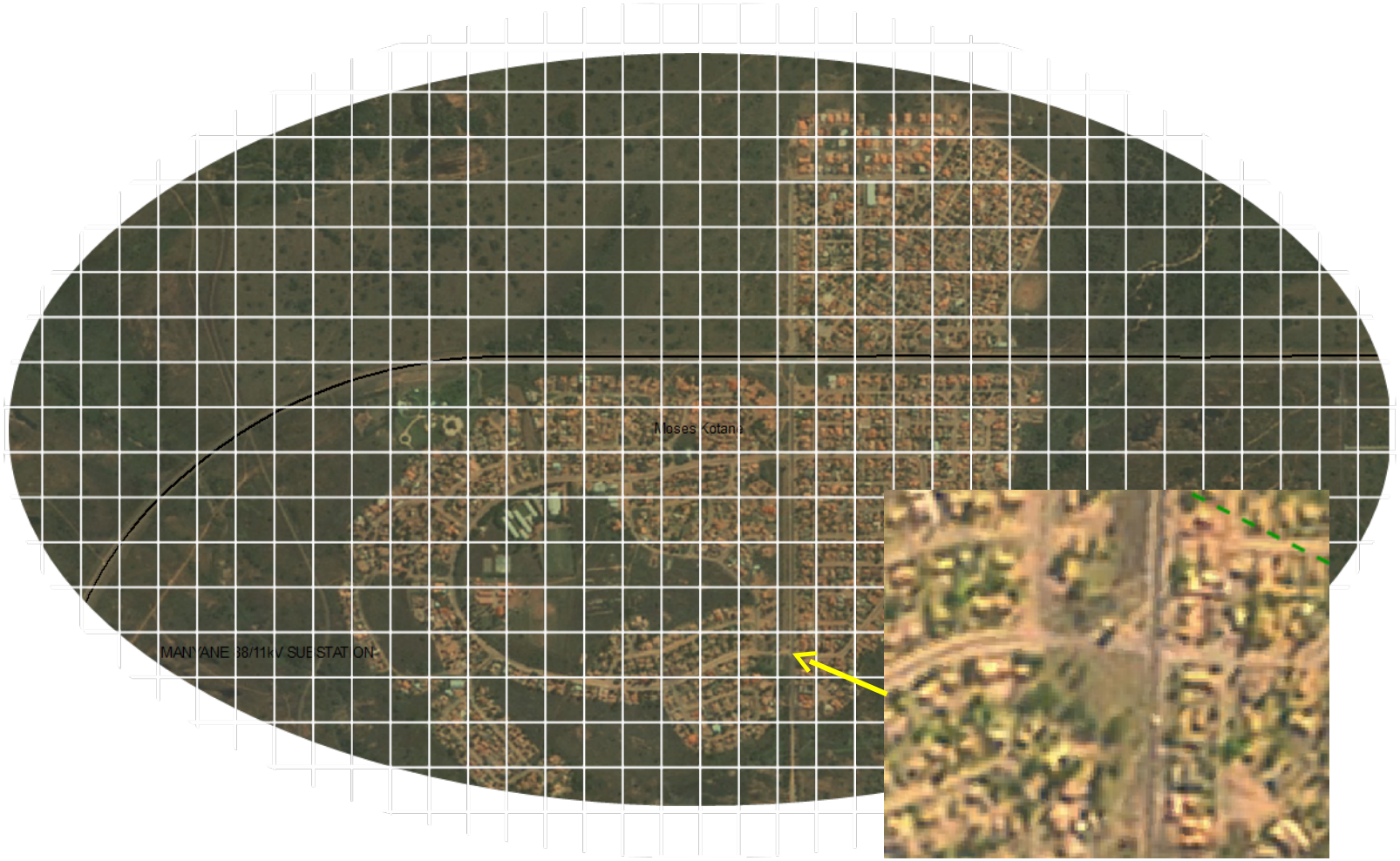
Based on all that has been explained, the supply feeder is forecasted to grow as shown.



Uniform Grid Method

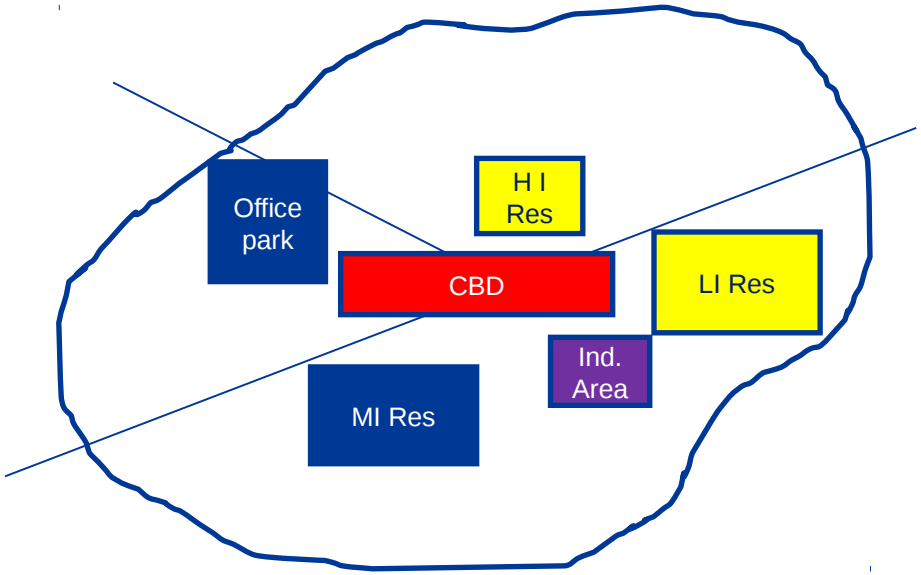


Uniform Grid Method



3. Mixing Load Profiles

Load Mixing



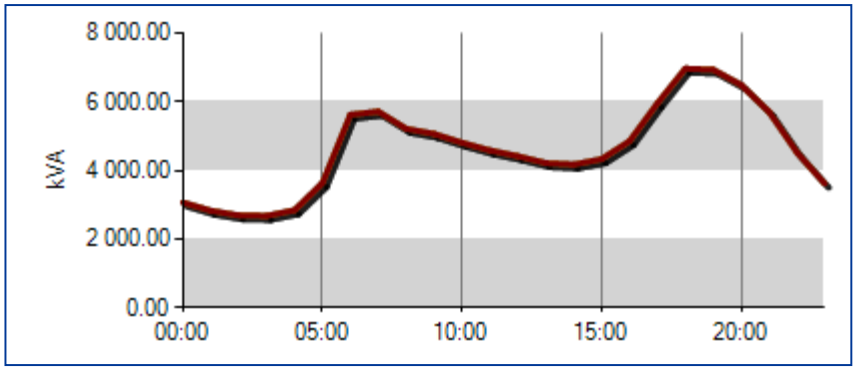
Development	Peak Load (MVA)
CBD	5
Industrial	5
Low Income Res	3
Med Income Res	3
Office Park	4
High Income Res	4
Total (undiversified)	24

Two transformers have been made available to supply the town and its surroundings. The apparatus are both rated 10MVA each.

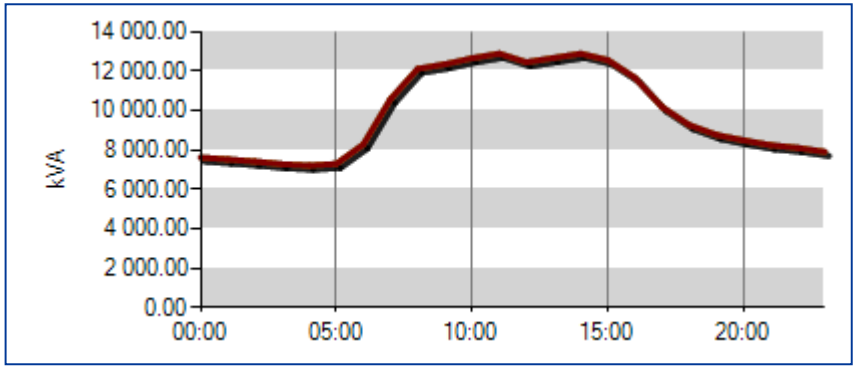
Supply Options and Resultant Profiles

Option 1

Transformer 1: HI Res, Low Income, Med Income

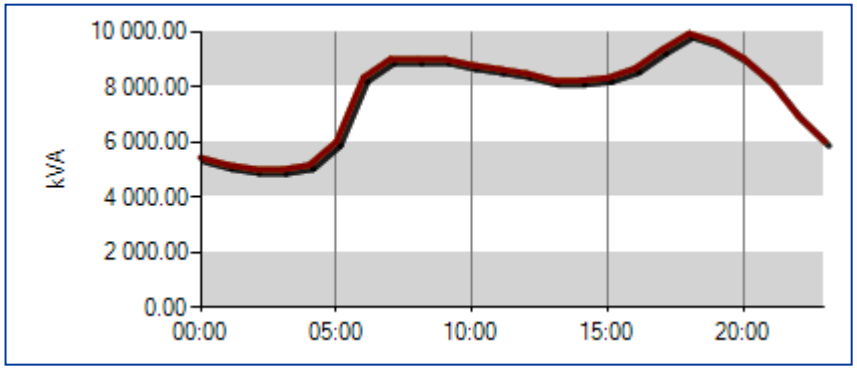


Transformer 2: Industrial, Office Park, CBD

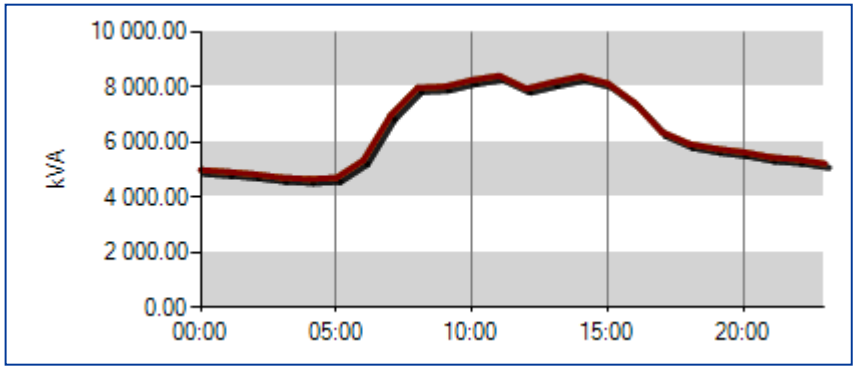


Option 2

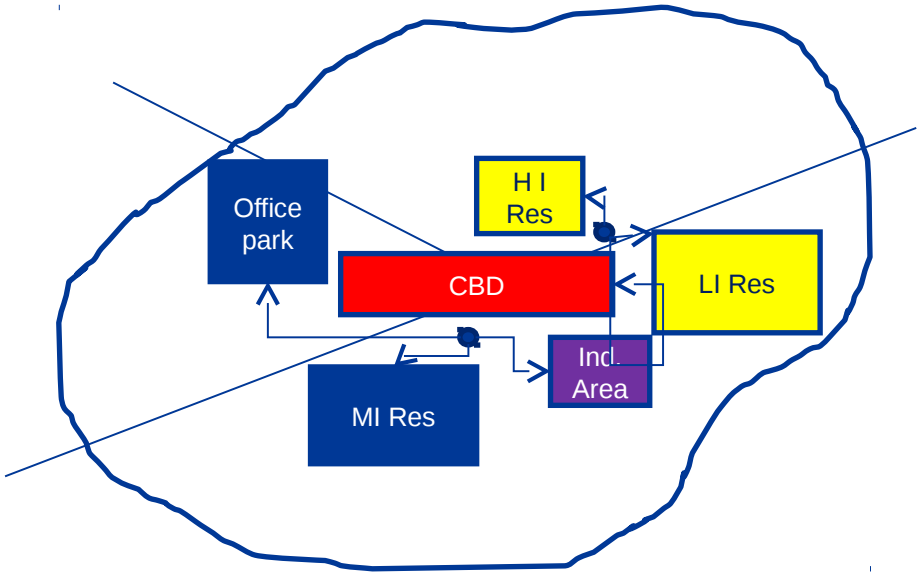
Transformer 1: CBD, HI Res, Low Income



Transformer 2: Industrial, Office Park, Medium Income



Supply Options



Development	Peak Load (MVA)
CBD	5
Industrial	5
Low Income Res	3
Med Income Res	3
Office Park	4
High Income Res	4
Total (undiversified)	24

DISCUSSION

•Option 2 combination provides adequate capacity but transformer Overrating chances are minimised due to high load factor.

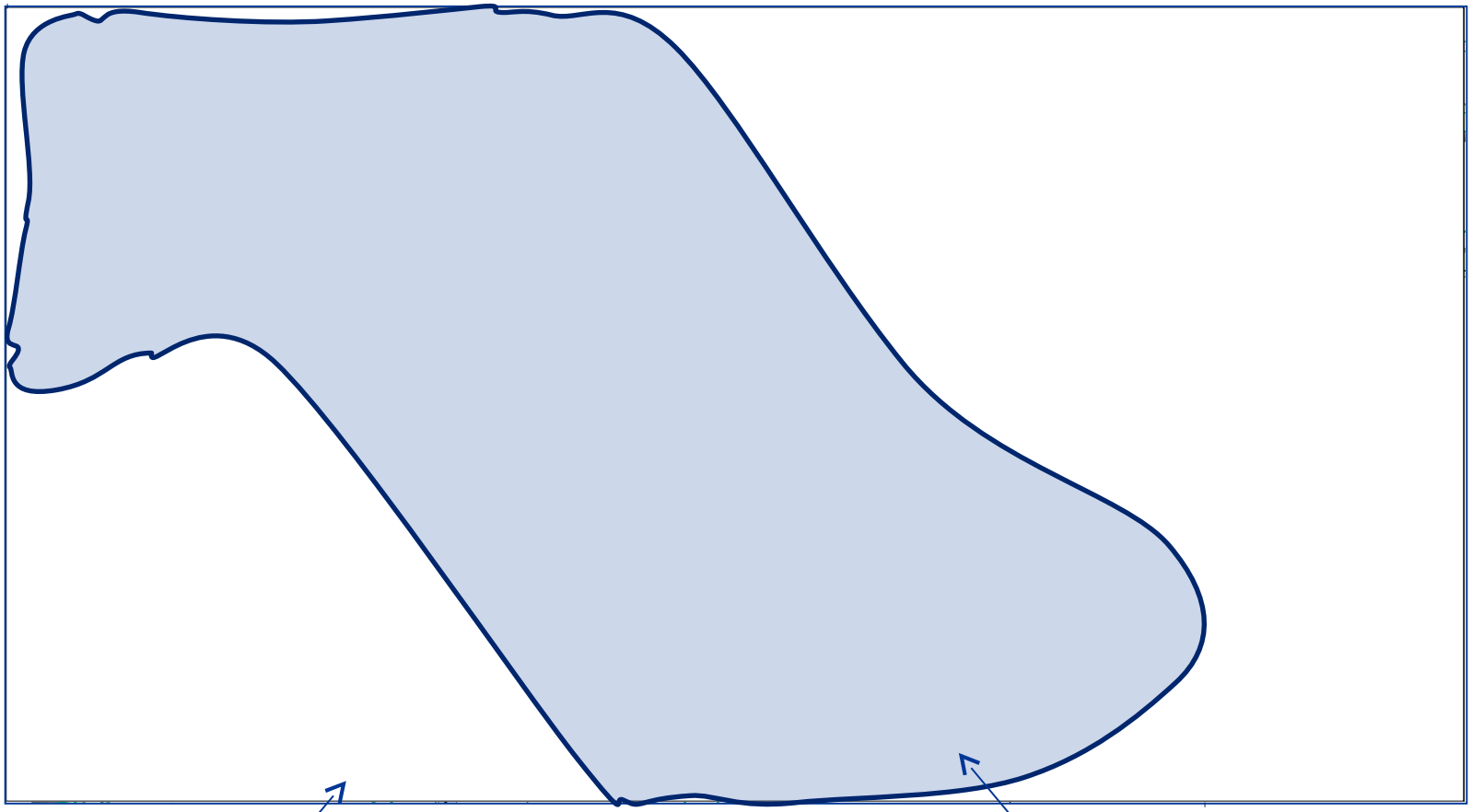
•Other issues such as line route and substation site selection need to be considered when attempting the load mix exercise.

•The alternative of putting both transformers in one substation may also be evaluated (This would lead to a favourable high level of load diversity, and therefore more capacity). This scenario gives a total peak of **16MVA.**

•Reliability and power quality issues need to be understood before the plan is finalised.

4. Potential Demand Perspecti

Feeder Area

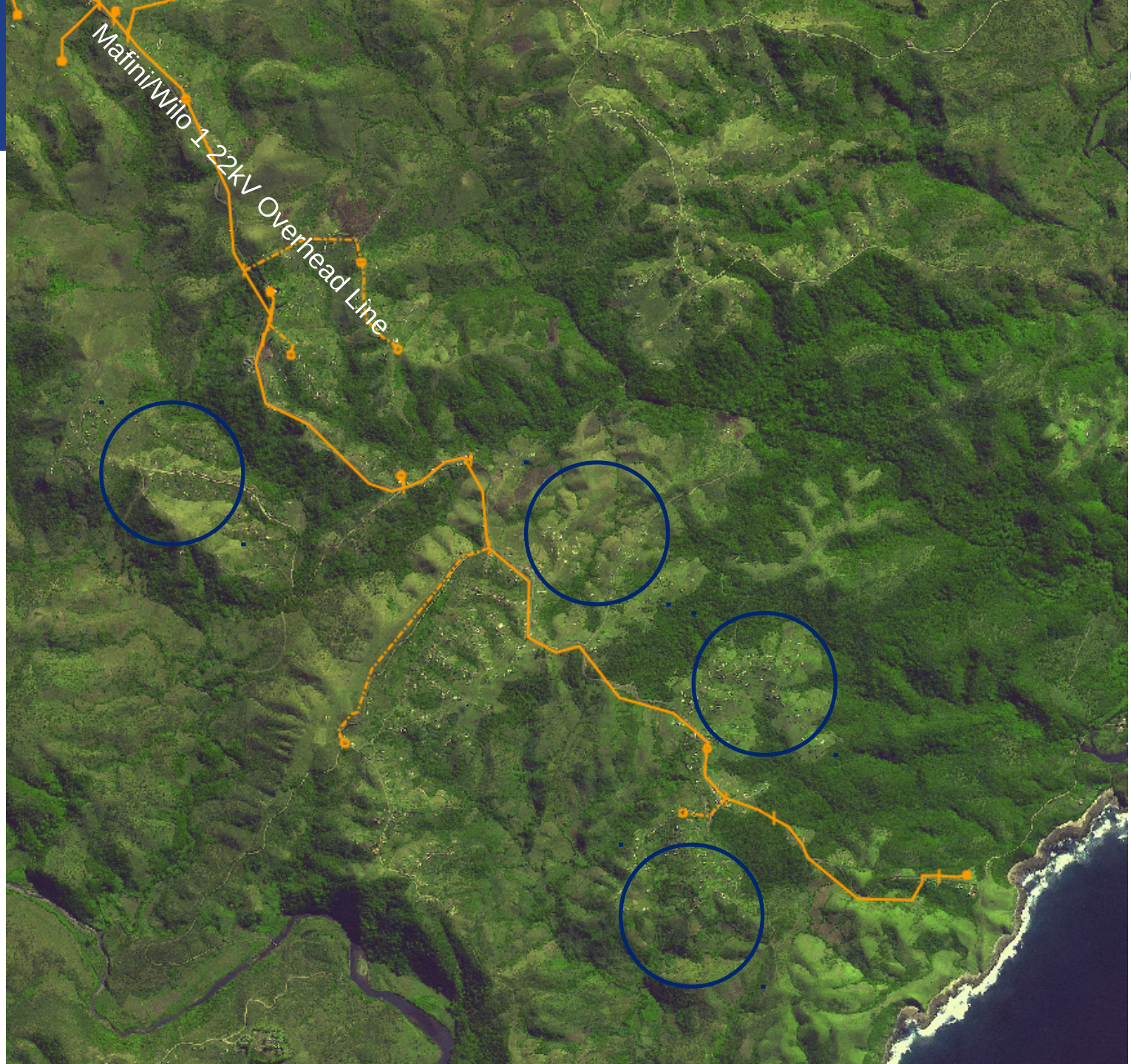


The feeder covers the above geographical area.

RurRes LD 1_2

RurRes MD 1_2

DESCRIBING THE SITUATION

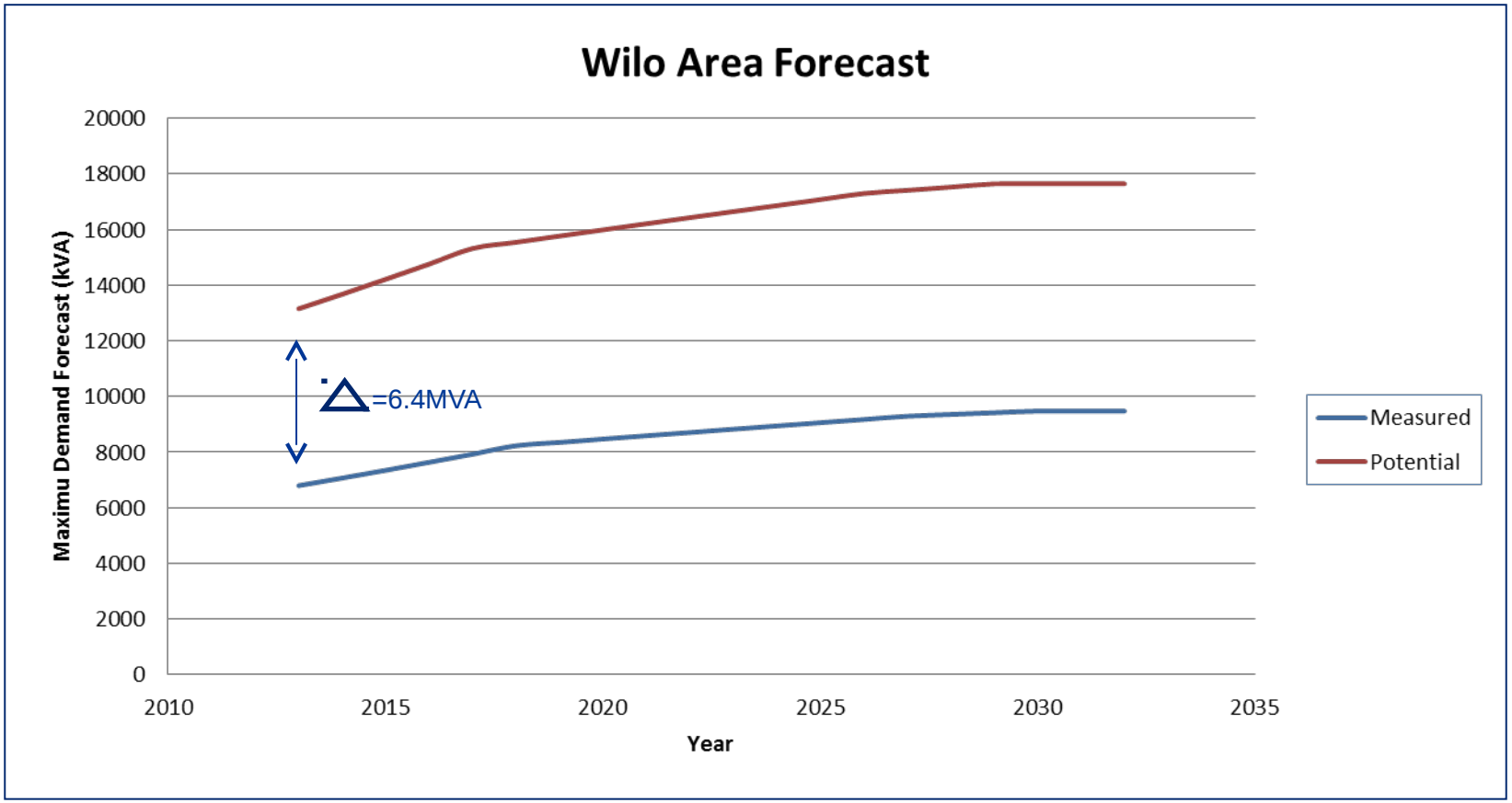


Eskom

Areas Not Supplied

DESCRIBING THE SITUATION

Measured and Potential Load



Quantification of the Potential Load on the Ground.

The “Delta”
What it means

- It shows the difference between what is supplied and what is not supplied.
- As soon as the infrastructure (feeder) is erected, this is the amount of load it will experience (Delta + Measured).
- During financial constraints, care must be taken to ensure that infrastructure rollout is prioritised. The size of the delta can be used as one of the indications/variables when performing prioritisation.
- The delta shows the MVA “backlog” of the area being studied.
- It can be used to calculate the “Energy Not Supplied” and the “Cost of Unsupplied Energy” that would be more significant to commercial/industrial customers.
- Cost to Customer = f {forecast, subclass}

5. Conclusion

Conclusion

- Proper load sub-classification leads to optimum planning, and inaccurate modelling/assigning of subclass may lead to inaccurate infrastructure plan.
- Load subclasses do change with both time and location – hence subclass regionalization and time-based maintenance framework.
- Load types (load factors) can be mixed and manipulated to save on infrastructure expansion expenditure. This can be carried out on existing and/or future infrastructure by the planner.
- The Potential Demand can be used for project prioritisation.
- As it has been mentioned that the small area forecast dates back to the 1950's, in the current century (21st), researchers need to look at process automation, integration, processor speed and accuracy improvements.
- Load behaviour understanding is important for capacity planning, reliability planning, electrification planning, economic evaluation of infrastructure plans, and also operators and designers.
- The ADMD needs to be assigned according to the LSM and the number of customers – not a "blanket" value.

Areas for possible improvement

- Training of planners: Using subclasses can be a tricky exercise…
- Automated Subclass Identification Mechanism: One can easily get the subclass wrong, thereby modelling the load type incorrectly. This can compromise the forecast accuracy…
- Load profile mixing: there is a need to develop a script that will perform this task as it can be a long trial and error, when manually performed.
- Input information: like any other computer program, PowerGLF forecast is as good as the input information. Input information is important.

Thank you