# Planning of SWER MV Networks

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# Key planning issues (SWER)

**Part 1 - Particular SWER parameters constraints)**

- Loading, balance and interference constraints.
- Components and specific design parameters
- Ferranti resonance on SWER schemes
- Conductor selection

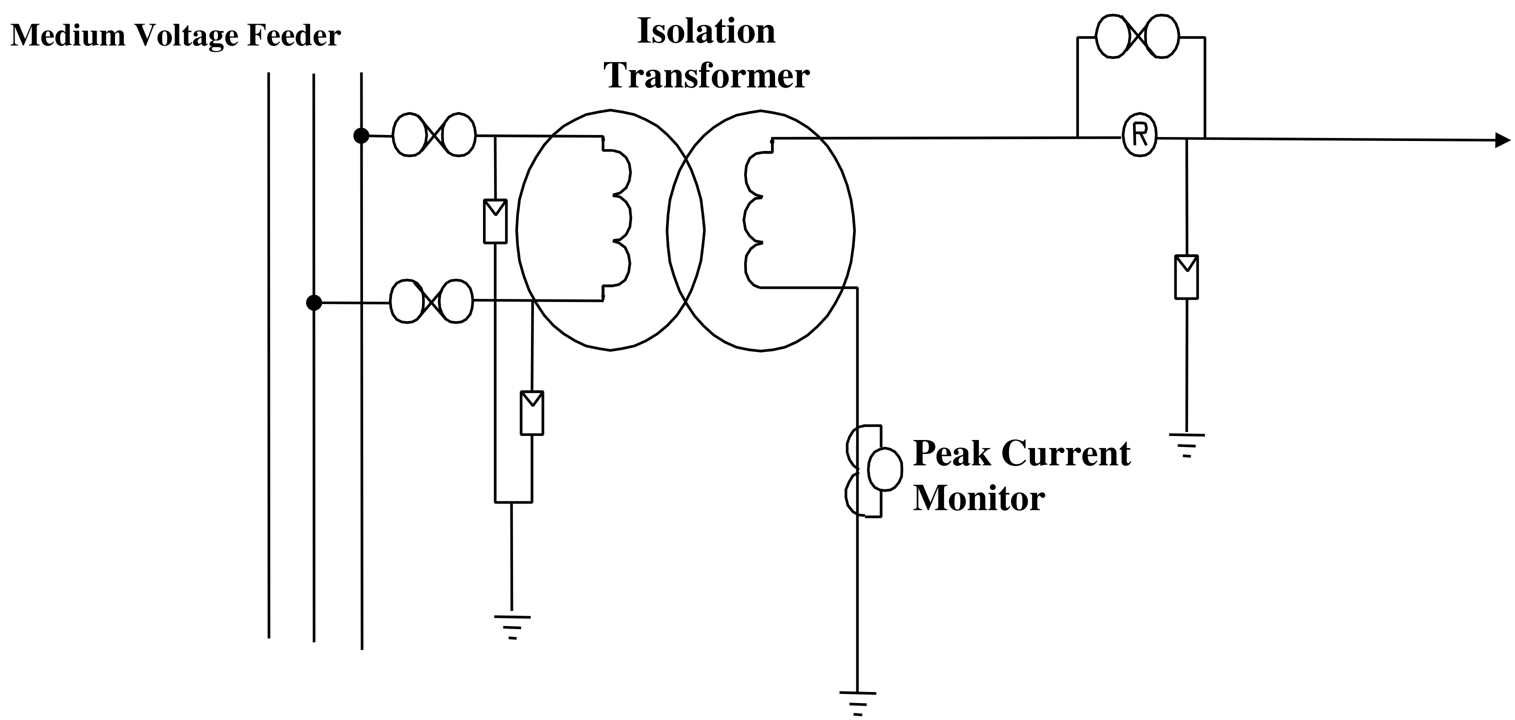
**Part 2 – Emerging electrification plan approach**

- Electrification plan (emerging)
- Detailed design reference based on the electrification plan - planning report.
- Project load estimates and upgrade considerations
- Unbalance considerations.

# SWER Constraints

- Peak Demand:   475 kVA (25A, 19.1kV)
- 3% Unbalance on 3 Phase Network
- Voltage range at customer supply points  - 230 V +- 10%, viz. 207-253V.
- Telephone Interference

# Peak Current Meter



# Break 1

# Eskom SWER Design Parameters

**Rated voltage 19.1 kV (33 kV phase-to-phase)**

**Maximum feeder current 25 A**

**Isolation transformers**
- **50 kVA**
- **100 kVA**
- **200 kVA**
- **400 kVA**

**Note: A 16kVA isolation transformer is not considered because of protection constraints and the small practical cost difference between a 16 kVA and 50 kVA isolation transformer.**

**Customer transformers**
- **16 kVA single-phase**
- **32 kVA dual-phase**
- **64 kVA dual-Phase**

# Eskom SWER Design Parameters

| | |
|---|---|
| Electrode voltage: | rod type 100 V |
| (Refer earthing section) | trench type 32 V |
| Maximum touch potential | <32 V |
| Line basic insulation level | >250 kV |
| Equipment insulation level | >200 kV |
| LV neutral MCOV (isolation transformer SWER) | 5 kV |
| LV neutral MCOV (33 kV source SWER) | 5 kV |

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# Gapless surge arrestor Ratings

| V system | U max | MCOV | V res. | Earthing |
|---|---|---|---|---|
| 11 | 12 | 10 | 40 | Non effective |
| 22 | 24 | 19.5 | 80 | Non effective |
| 33 | 36 | 24 | 100 | Effective (SWER) |
| 33 | 36 | 29 | 120 | Non effective |

# Break 2

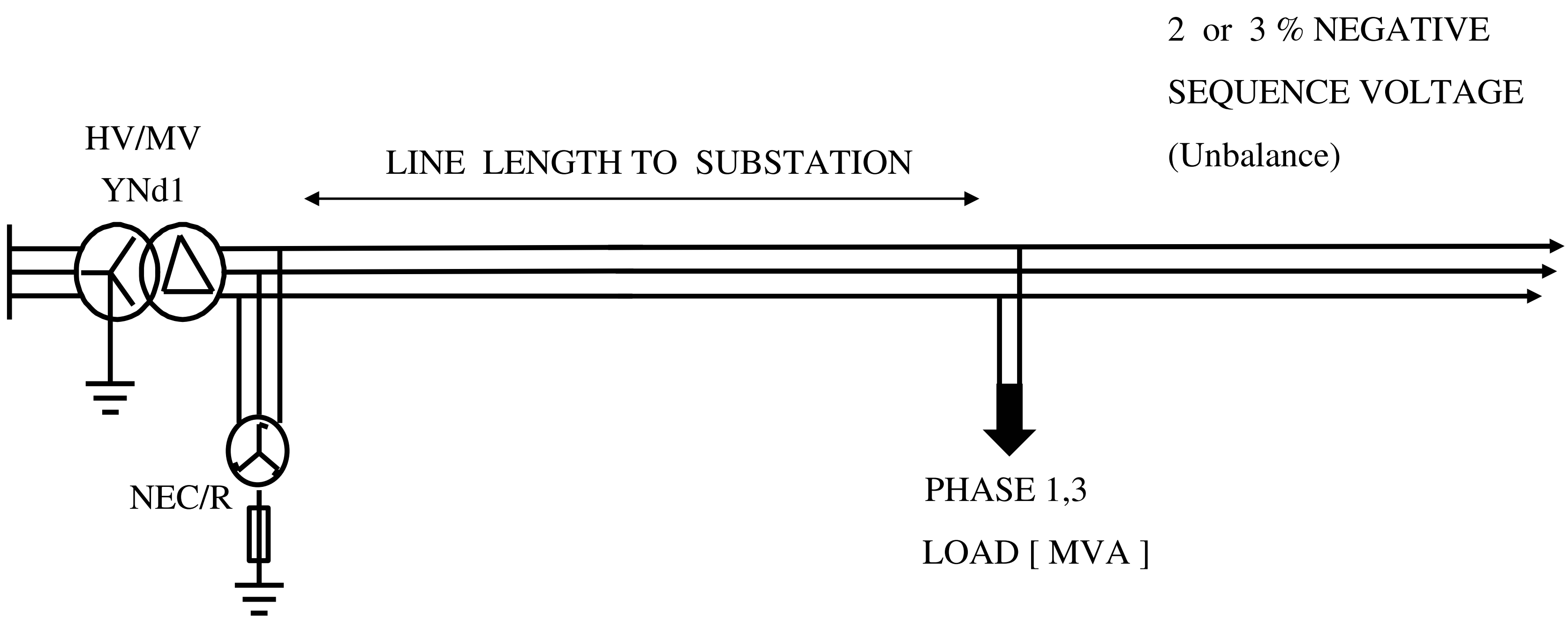
# Voltage imbalance

**Voltage Unbalance:** Voltage Unbalance occurs when the voltage magnitude of the 3 phases is different. It is defined as the ratio of the negative phase sequence voltage to positive phase sequence voltage, expressed as a percentage. It is calculated as follows (reference standard ASAAJ3-1).

Unbalance $\sqrt{\frac{1-\sqrt{3-6\beta}}{1+\sqrt{3-6\beta}}}$ where $\beta = \frac{U_{AB}^4 + U_{BC}^4 + U_{CA}^4}{(U_{AB}^2 + U_{BC}^2 + U_{CA}^2)^2}$ and U is the RMS line to line voltage

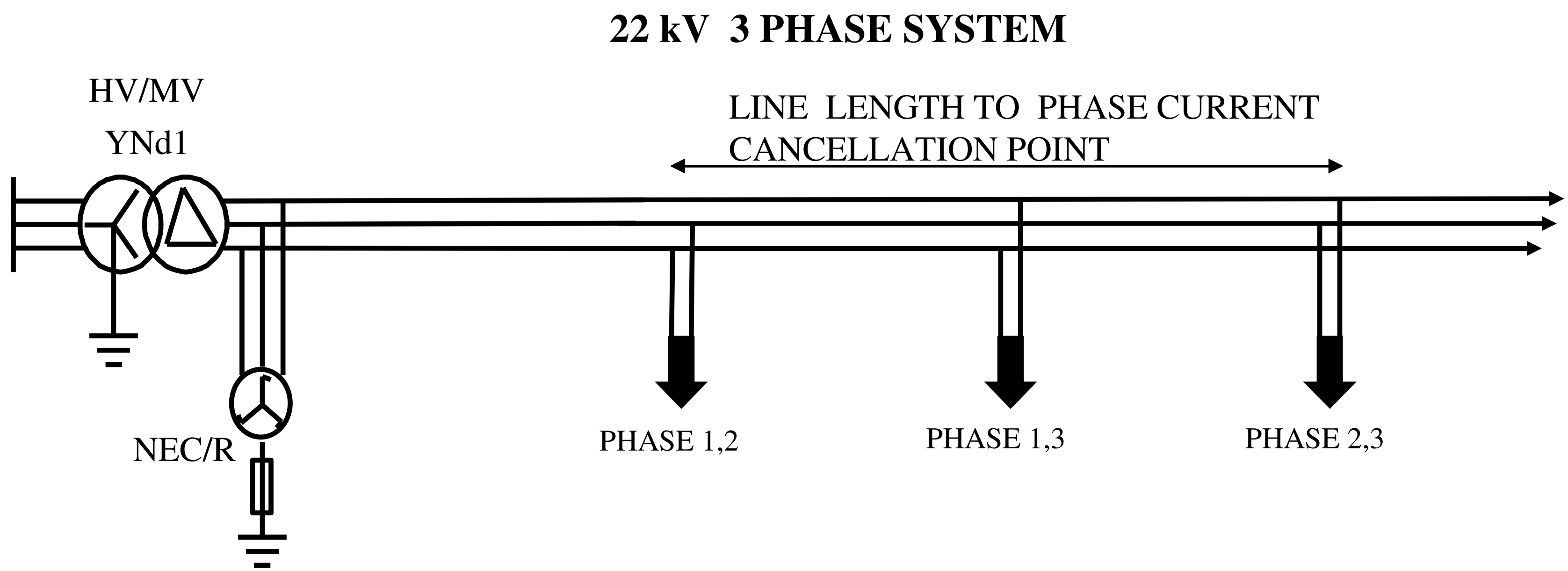
# Single Phase Unbalance

**22 kV 3 PHASE SYSTEM**



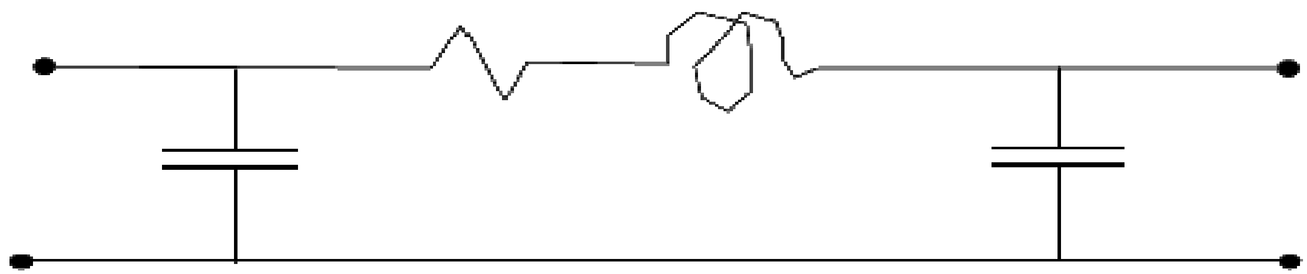

**THE EFFECT OF TWO PHASE LINE TAP-OFF FROM A 22 kV ESKOM LINE**

# Single Phase Unbalance




**THE EFFECT OF TWO PHASE LINE TAP-OFFS FROM A 22 kV ESKOM LINE**

# Ferranti Effect



| Ferranti Effect: | | |
|---|---|---|
| Total Line Length | Charging Current | % Voltage rise |
| 10 km | 0.13 A | 0.01% |
| 50 km | 0.65 A | 0.15% |
| 100 km | 1.31 A | 0.61% |
| 200 km | 2.67 A | 2.40% |
| 400 km | 5.68 A | 8.77% |
| 600 km | 8.95 A | 14.34% |

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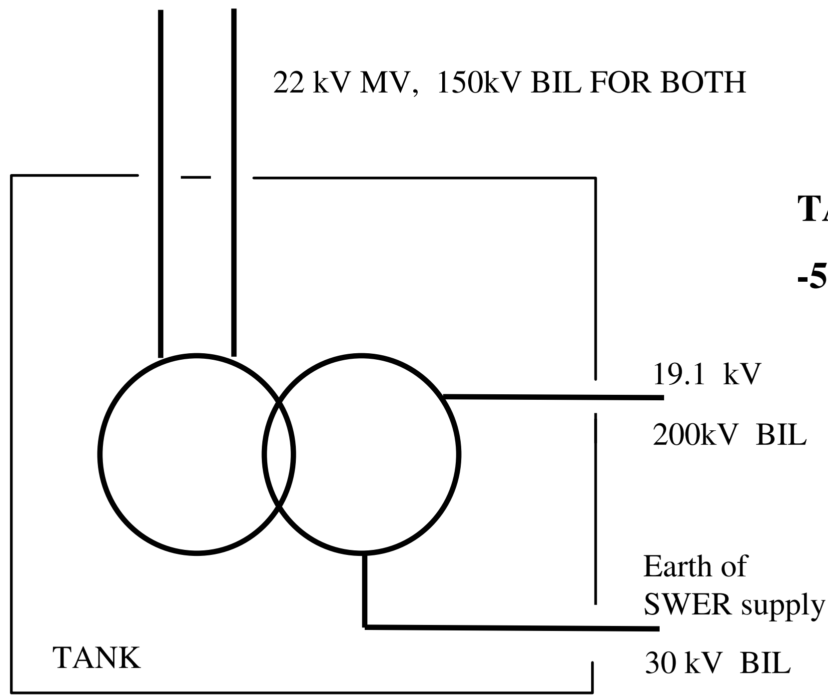
# Break 3

# Isolation Transformer

## 500 kVA ISOLATION TRANSFORMER FOR SWER SYSTEMS



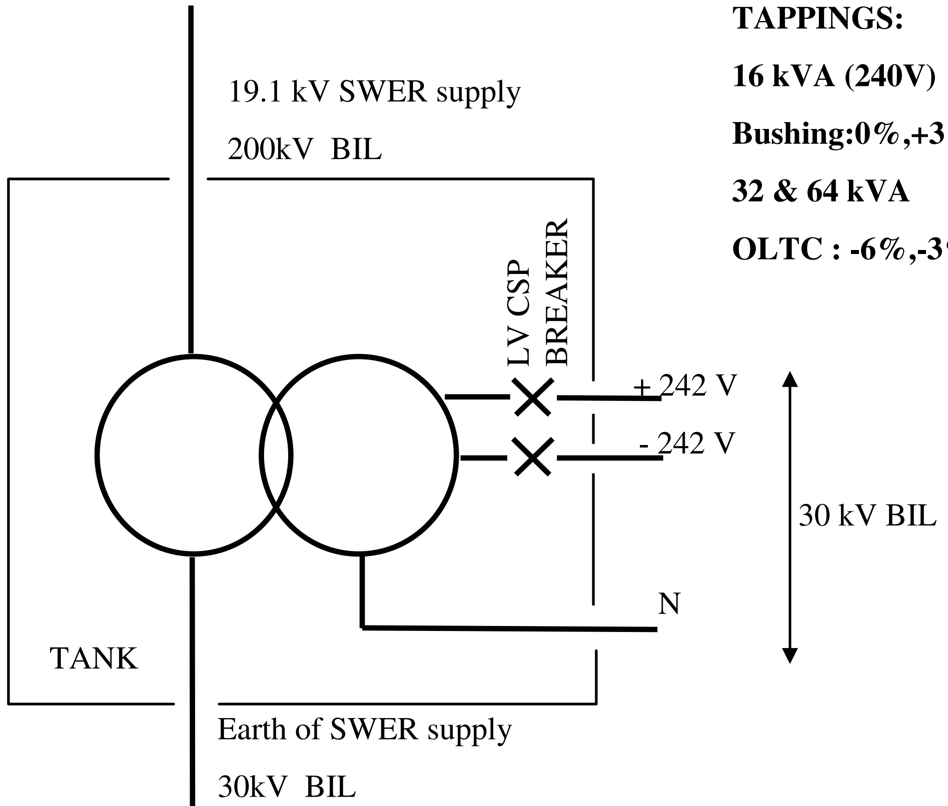

**TAPPINGS: OLTC**

**-5%,-2.5%,0%, +2.5%, +5%**

# SWER Customer Transformer

**16 and 32 kVA TRANSFORMER, DUAL PHASE LV**

**FOR 19.1 kV SWER SYSTEM**




**TAPPINGS:**

**16 kVA (240V)**

**Bushing:0%,+3%,+3%**

**32 & 64 kVA**

**OLTC : -6%,-3%,0%,+3%,+6%.**

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# Break 4

# Conductor options - Refer structures

- On the basis of limited (planned) loads, line lengths and upgrade paths normally light conductor rage is applied –

- AAAC – Acacia.(7*2.08)
  - All aluminium alloy
  - Relatively low uts and strength dependant on all strands
  - Susceptible to vibration damage
  - Coastal and polluted areas

- ACSR – Squirrel (6/1*2.11)
  - Aluminium conductor steel reinforced
  - Cost effective flat terrain

- ACSR (extra strong) Magpie.(3/4*2.12)
  - Three aluminium, 4 steel strands
  - High uts value, relatively robust.
  - Ideal for long spans and undulating terrain.

# Conductor options - Refer structures

| Conductor | Point Load(minimum case) | | Distributed load (typical case) | |
|---|---|---|---|---|
| | 5%voltage-drop | 10% voltage-drop | 5% voltage-drop | 10% voltage-drop |
| Fox | 41 km | 82 km | 82 km | 164 km |
| Squirrel | 27 km | 53 km | 53 km | 107 km |
| Magpie | 14 km | 28 km | 28 km | 56 km |
| Bantam | 8 km | 15 km | 15 km | 31 km |

Assumption: Line lengths based on 25A load at 19,1kV.

# Break 5

# Determine the prospective life cycle loading on the affected system

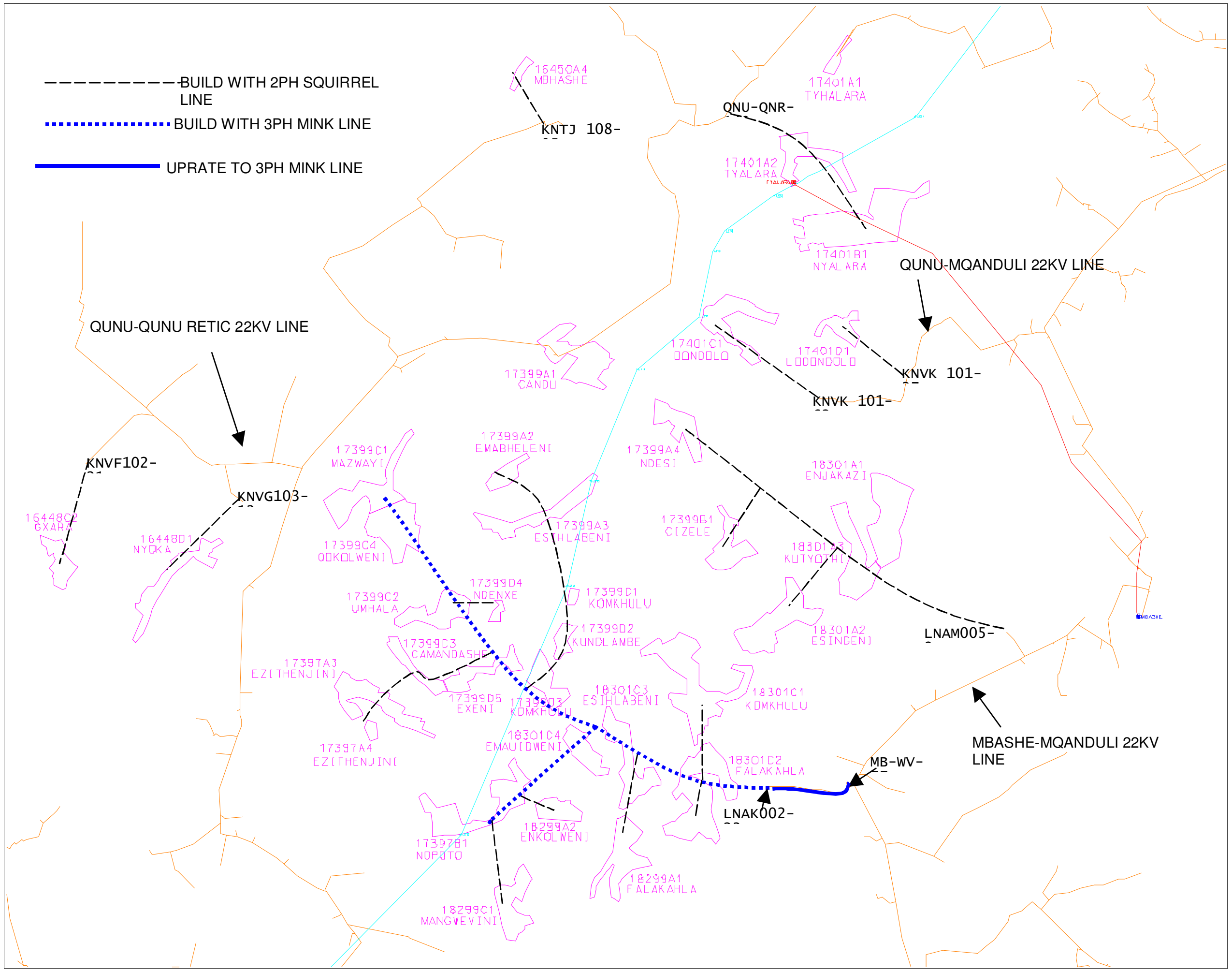
- Customer load estimating;
  - Design tools - Eskom has DT PET (applicable to SA situation) to enable parameter and pu electrification load determination – See design tools section.
  - Deterministic methods, calculation tables with diversity factors.
  - Forecast load growth on a time line, particularly emerging networks and mass electrification.

# Load estimation & project parameters

| Criteria | Issue | | Specified Minimum Requirement | Value offered | Reason and/or comments - CPE to provide short summary and design repo |
|---|---|---|---|---|---|
| **MV System** | | | | | |
| | Sys. Config: | SWER | TBC | **Yes** | One spur of 17km |
| | | 2 phase | TBC | **Yes** | Confirm the use of 2 Phase technology as per Planning Report - Utilised Aquirre |
| | | 3 Phase | TBC | **Yes** | Two spurs proposed by planning report - 22km - constructed in 3 Phase (1740, 1 |
| | Voltage intake at | | Design/No load | | |
| | | As per Planning report: | | | |
| | | 33 Vilages | 99%-102% | **99%-102%** | Where low load voltages exceed 100% , Maximum of 2,5% / 3% boost on 242V |
| | Protection: | Recloser Reqd. | Yes | **Yes** | Required on the Mbashe Mqanduli 22kV network - Existing Take off at LNAK002 |
| | | Transformer switch | Yes | **Yes** | A link or MV Cut out unit per transformer supplied as per instruction. Confirmed |
| | | Pole BIL wires reqd. | Yes | **Yes** | All intermediate structures except stayed and shared structures and structures i |
| | Voltage | Regulator at: | No | **No** | Not required. |
| | support | Capacitor at: | No | **No** | Not required. |
| **Indicators** | | | | | |
| | Scope | No of connections | 2698 | **2698** | |
| | Density | m²/Connection | TBP | **8897** | Calculated from the overall layout |
| | ADMD (kVA) | | | | |
| | | Initial | | | ***Alternative:*** ***Initial*** ***Final*** |
| | | Final | | | ***Alpha*** ***0.25*** ***0.32*** **Comply** |
| | CB setting | Initial | | | ***Beta*** ***1.86*** ***1.41*** **Comply** |
| | | Final | | | ***CB*** ***20*** ***20*** **Comply** |
| | DCF | | | | ***ADMD*** ***0.55*** ***0.86*** **Comply** |
| | UCF | | As reqd. | | **Max trfr loading 130% - Setting in ReticMaster at AMEU currents.** |
| | Maximum LV radial feeder length. (Limitation applies to 90 % of project) | | 550 m | **750** | Fault level at end of line within specification of 1.6x80A |
| | Protection | MV fuse sizes | | **20 Amp** | Group fusing - Fuse inserts - 20A K-type as per Eskom specification as per SLD |
| | | LV min fuse size | 63 Amp | **80 & 63 Amp** | EBM or HA Type as per Eskom standard specification. Mostly 80A fuses will be u |
| | Metering | | | | |
| | | LV/Bulk/Comb | Yes | **No** | Not required as per planning report. |

# Electrification distribution plan-Discussion example

**Phase 1**




Planning report - Idutywa phase 5 Electrification.doc

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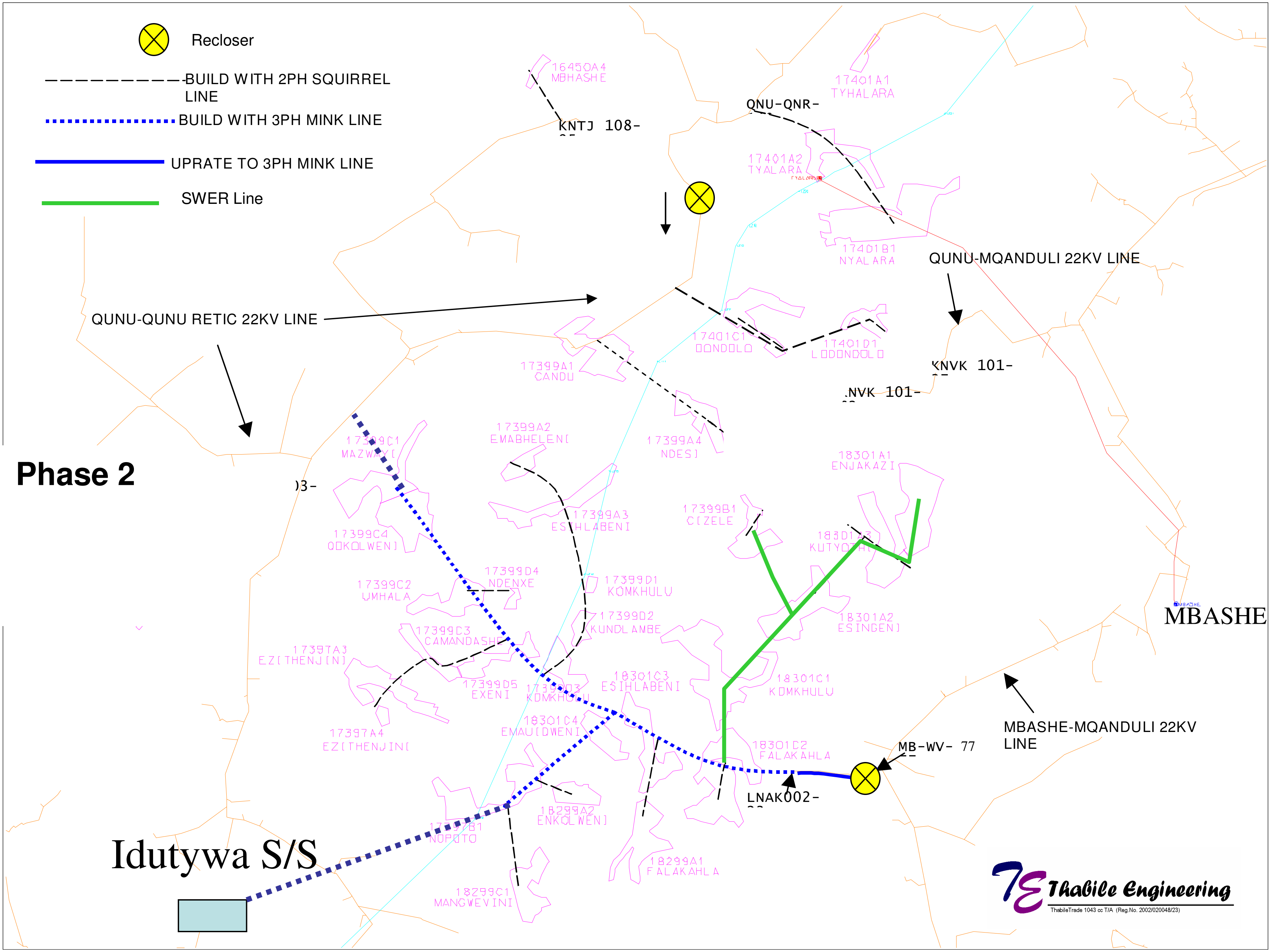
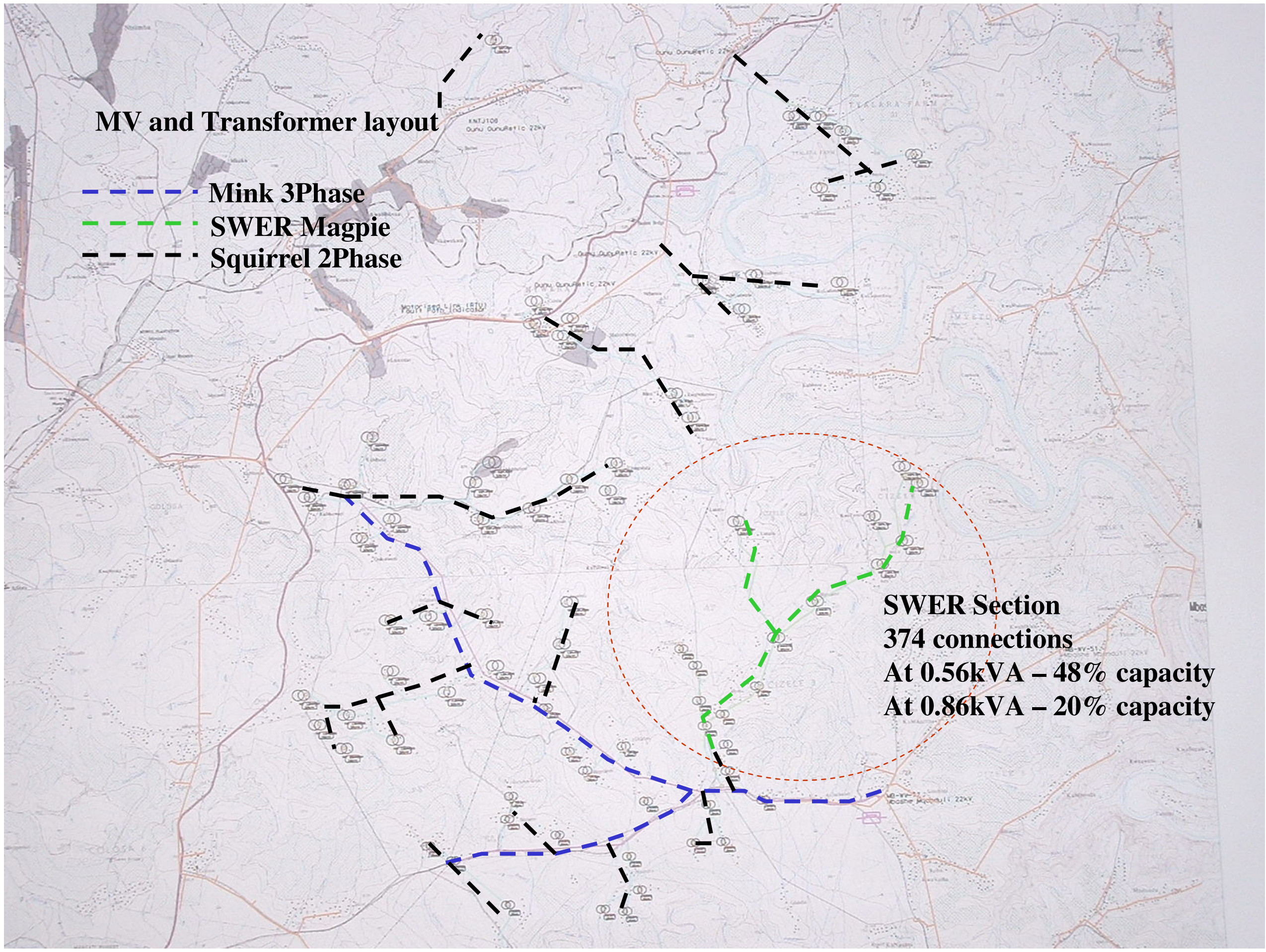

Recloser
BUILD WITH 2PH SQUIRREL LINE
BUILD WITH 3PH MINK LINE
UPRATE TO 3PH MINK LINE
SWER Line
Phase 2
QUNU-QUNU RETIC 22KV LINE
QUNU-MQANDULI 22KV LINE
MBASHE-MQANDULI 22KV LINE
Idutywa S/S
MBASHE
KNTJ 108-
QNU-QNR-
KNVK 101-
NVK 101-
MB-WV- 77
LNAK002-
16450A4 MBHASHE
17401A1 TYHALARA
17401A2 TYALARA
17401B1 NYALARA
17401C1 DONDOLO
17401D1 LODONDOLO
17399A1 CANDU
17399A2 EMABHELENI
17399A4 NDESI
17399C1 MAZWAYI
17399A3 ESIHLABENI
17399B1 CIZELE
18301A1 ENJAKAZI
17399C4 QOKOLWENI
17399D4 NDENXE
17399C2 UMHALA
17399D1 KOMKHULU
17399D2 KUNDLAMBE
18301A2 ESINGENI
17399C3 CAMANDASHE
17397A3 EZITHENJINI
17399D5 EXENI
18301C3 ESIHLABENI
18301C1 KOMKHULU
18301C4 EMAUIDWENI
17397A4 EZITHENJINI
18301C2 FALAKAHLA
18299A2 ENKOLWENI
18299A1 FALAKAHLA
18299C1 MANGWEVINI
Thabile Engineering
ThabileTrade 1043 cc T/A (Reg.No. 2002/020048/23)

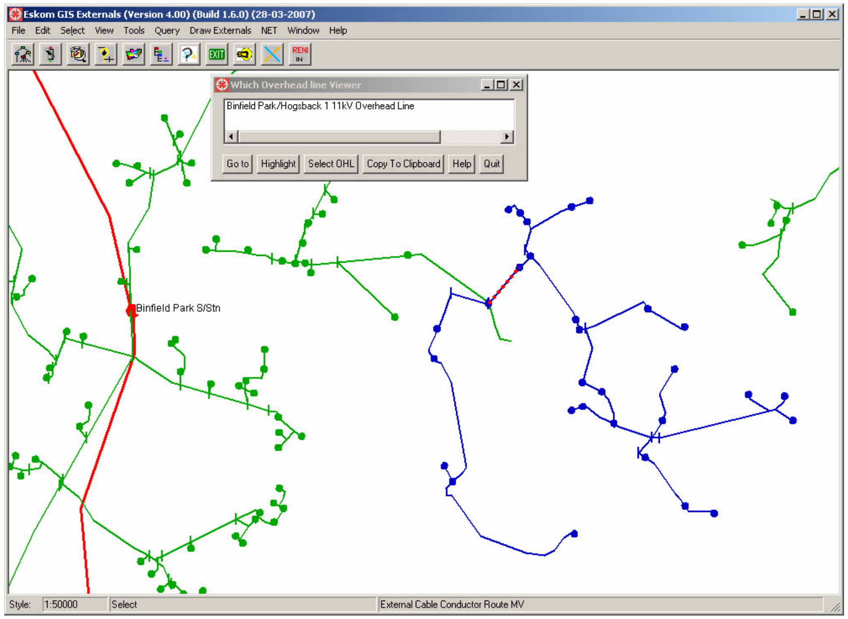
# Proposed configuration in terms of the electrification distribution plan including MV upgrade consideration (MV)



# Break 6

# SWER Upgrade options

- **Extend system – Convert to 3 phase and move isolation transformer position.**
- **Split system at isolation transformer point (ideal as existing electrodes are used.)**
- **New in feed positions provided.**

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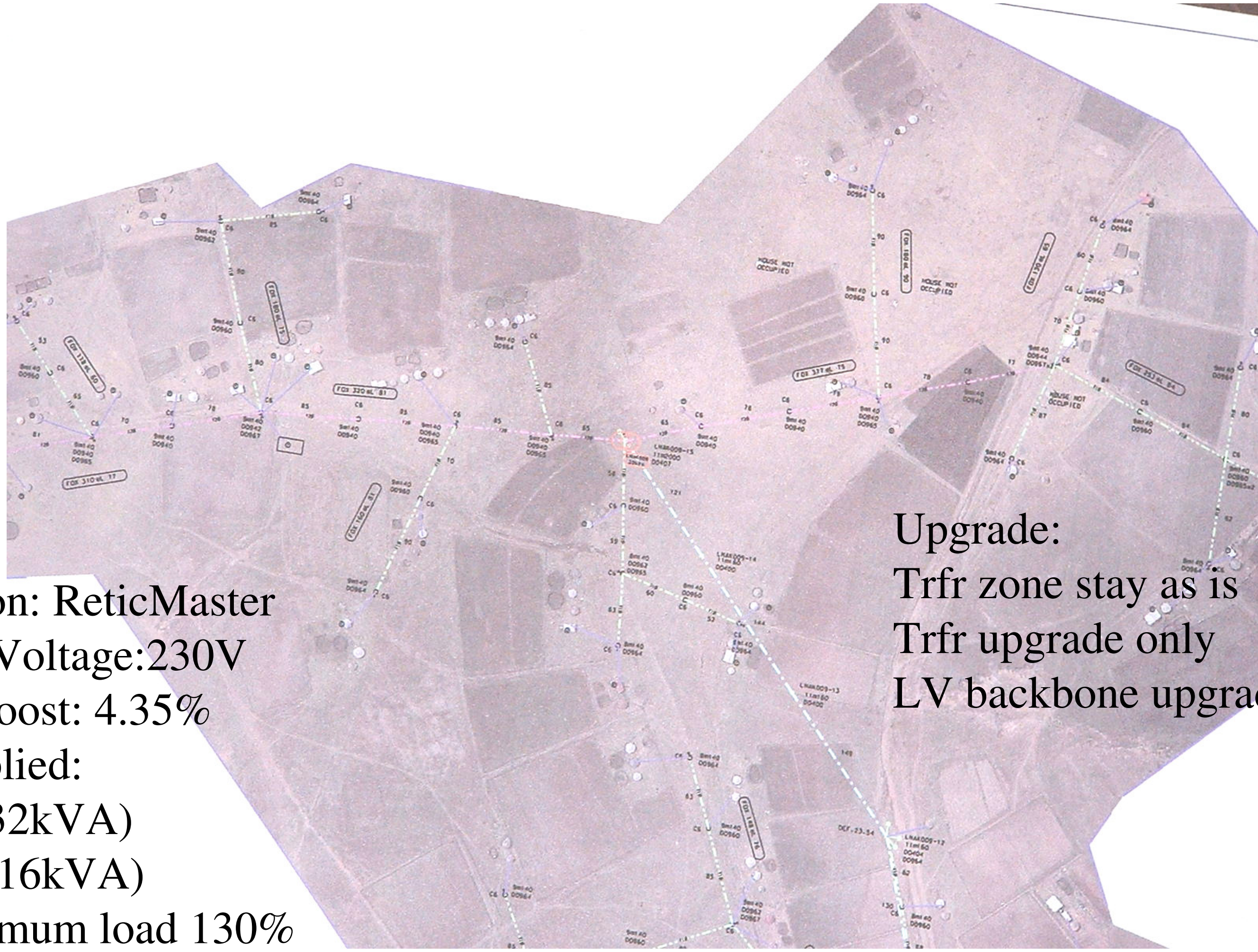
# Typical LV design, parameters and upgrade options



Calculation: ReticMaster
Nominal Voltage:230V
Internal boost: 4.35%
Boost applied:
3%max (32kVA)
0% max (16kVA)
Trfr maximum load 130%

Upgrade:
Trfr zone stay as is
Trfr upgrade only
LV backbone upgrade only

# Conclusion

For Rural electrification expansion

- Be mindful of the specific SWER constraints & SWER parameters
- Identify viable SWER schemes in the context of the emerging electrification plan
- Include phased implementation in the project motivation/specification

**Thank you**

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