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Stellenbosch Municipality

Network Planning Criteria

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TABLES

1 INTRODUCTION

Distribution networks owned and operated by the Stellenbosch Local Municipality (SLM) consist of 66 kV and 11 kV networks.

Additions and reconfigurations to these networks in the form of extra:

- Distribution lines and distribution feeders,
- Substations and transformers,
- Loads, and
- Capacitors or reactors.

will produce an impact on the existing networks.

Stellenbosch is responsible for the network security, reliability and quality of supply to all network users. Stellenbosch technical requirements are intended to ensure that a high level of service reliability is maintained when additions and changes to the networks or user's installations are made. Technical requirements are based on the rules, criteria and limits included in these Network Planning Criteria.

This document presents the planning criteria applied to ensure that Stellenbosch networks:

- Provide and adequate electricity supply,
- Meet safety standards,
- Effectively utilize equipment, and
- Ensure that network losses are contained within reasonable limits.

The philosophy of network planning and the rationale behind the planning criteria are discussed in Section 2 of this document. The guidelines for network planning, which are given in Section 3 of this document, outline the range of technical planning criteria.

The purpose of planning criteria is to help obtain a balance between the user's need for a safe, secure, reliable electricity supply and the desire for this service to be provided at the least cost.

2 DESIGN PHILOSOPHY

The planning criteria are used to assess network capacity and determine the need for and timing of network expansion, reinforcement or re-configuration. Network reinforcement plans are then developed which will satisfy the planning criteria and network constraints.

2.1 Network Design Philosophy

Stellenbosch Local Municipality designs its distribution systems as meshed networks, though invariably there will be radial distribution feeders in some developing areas.

The planning philosophy for these meshed networks is that the loss of any one component of the network at a time of peak load will not result in the loss of supply to any customers. This is referred to as the 'N-1' criterion, which can result in imprudent capital expenditure. Prudent capital expenditure involves the application of risk management techniques. This requires a consideration of the probability of an event occurring and the consequences of its occurrence, for example the impact on customers. If the probability is low and the consequences minimal, it may be considered justified delaying system reinforcement beyond the date indicated by the N-1 criterion.

In urban areas the density of users often results in an open, meshed network that is run radially with open points. This operating mode minimises fault levels and simplifies technical and operational requirements. In these situations improved supply restoration times are possible, although the initial loss of supply will still occur.

In rural areas the distribution network is, generally, radial and interconnection to reduce supply restoration times is often not possible.

2.2 Network Capacity Assessment and Reinforcement Needs

Network capacity and the need for network reinforcement are assessed by comparing the planning criteria with network performance for:

- Increasing load levels and load growth in new areas,
- Particular load characteristics, and
- Performance / Reliability improvements.

To satisfy the performance levels, least cost plans are developed. The extent of the network reinforcement work is dependent on:

- The load forecast,
- The anticipated maximum demands of all users,
- User load profiles,
- Minimizing losses, and
- Age and condition of existing assets.

Financial evaluation is used in assessing network reinforcement requirements and serves three functions:

- It indicates the return to Stellenbosch on proposed capital investment,
- It assists in ranking projects, and
- It helps to choose between options.

3 NETWORK PLANNING CRITERIA

Network Planning Criteria are a set of standards applied to maintain network adequacy and reliability. They are used as a planning tool to protect the interests of all network users in terms of reliability and adequacy. The criteria are also applied to protect networks against instability.

3.1 Steady-State Criteria

The steady-state criteria define the adequacy of the network to supply the energy requirements of users within the component ratings and voltage limits, taking account of planned and un-planned outages.

The steady-state criteria apply to the normal continuous behaviour of a network and also cover post-disturbance behaviour once the network has stabilised after an outage.

In the following sub-sections, the various components of the steady-state planning criteria are defined.

3.1.1 Steady-State and Contingency Voltage Limits

3.1.1.1 Steady-State Voltage

The network shall be designed to achieve a continuous network voltage at a user's connection not exceeding the design limit of 105% of nominal voltage and not falling below 95% of nominal voltage during normal and maintenance conditions.

3.1.1.2 Contingency Voltage

The network shall be designed to achieve a steady-state voltage within:

± 5% of the nominal voltage during normal conditions,

± 8% of the nominal voltage during planned maintenance conditions, and

± 10% of the nominal voltage during un-planned outage conditions.

3.1.2 Thermal Rating Limits

The thermal ratings of network components shall not be exceeded under normal or emergency operating conditions when calculated on the following basis:

1. Transformers: Normal manufacturer's name plate rating.

   Note: Transformers are capable of significant short-term overloads because of the thermal inertia of the core. The main concern however is with cyclic loading and the effect of extended periods of overload on the life of the transformer insulation since ageing effect is cumulative. If the transformer has cooling equipment, the rating above nominal with cooling is enhanced considerably and the effect of hot spot temperatures mitigated. It is permissible to overload the transformer for short periods on the basis that for the remainder of the time the use of life will be less than normal. Examples of typical rating definitions are those of long-term emergency (LTE) rating, specified as the amount of load the transformer can carry while suffering 1 percent "loss of life", and the short-term emergency (STE) rating that allows two-times the transformer nameplate rating for 15 minutes. These factors can be incorporated into maintenance and analysis programs within Stellenbosch, where certain aspects with regard to the transformers approaching their thermal limits are monitored and informed decisions can be made with regard to additional investment requirements.

For each class of transformer, general limitations on current and temperature are recommended as listed in IEC354 Loading Guide for Oil-Immersed Transformers. These values provide a broad "operating envelope" which may be greatly affected by the following:

- Load Profile (Duration and Peak),
- Ambient Conditions,
- Assumption of transformer thermal characteristics,
- Voltage limitations, and
- Capability of transformer accessories.

It is thus recommended that the nameplate thermal rating is used for planning purposes. Once a specific transformer approaches its nameplate thermal loading limits, an informed decision, backed by physical measurements and sample tests, should be made with regard to the upgrade strategy.

2. Switchgear: Normal manufacturer's name plate rating,
3. Overhead Lines: Rating based on ambient temperature of 75°C under normal conditions and 90°C under contingency conditions,
4. Cables: Normal cyclic rating, with maximum operating temperatures of 90°C for XLPE cables; 70°C for 11 kV paper insulated cable and 65°C for 11 kV paper insulated cables.

3.1.3 Fault Rating Limits

For safety reasons, the fault rating of any equipment shall not be less than the fault level in that part of the network at any time and for any normal network configuration.

The average estimated fault levels on Stellenbosch networks are shown in Table 3-1 below.

Table 3-1: Stellenbosch / Franschhoek Fault Levels

Substation	Voltage	1 Phase	3 Phase
Main	66kV	3,633kA	4,389kA
Cloetesville	66kV	3,087kA	3,918kA
Franschhoek	66kV	1,676kA	1,785kA

Equipment owned by Stellenbosch is designed to withstand these fault levels for 1 second.

3.2 Contingency Criteria

Contingency criteria relate to the ability of the network to be reconfigured after a fault so that the un-faulted portions of the network are restored.

3.2.1 Urban Distribution Feeders

Distribution feeders in urban areas shall be planned and designed so that, for a substation feeder circuit or exit cable fault, the load of that feeder can be transferred to adjacent feeders by manual network reconfiguration.

Where practical, the network shall be planned and designed so that, in the event of a failure of a substation transformer, all of the load of that transformer can be transferred to other transformers within the same substation or adjacent substations.

3.2.2 Rural Distribution Feeders

The radial nature of rural distribution feeders normally precludes the application of contingency criteria to these feeders. However, where reasonably achievable, interconnection between feeders shall be provided, and reclosers and sectionalisers shall be installed to minimise the extent of outages.

3.3 Conductor Selection Criteria

Stellenbosch generally uses underground cables for distribution circuits and overhead conductors at the outskirts of town.

In designing extensions to the network, ultimate load horizon planning shall be used to establish the network concept plan and the initial installation shall conform to that concept plan and use carriers that are appropriately sized. This methodology eliminates the need to disrupt the community in future years as load growth occurs and results in the minimum lifetime cost to the community.

To achieve maximum cost efficiency in the installation of conductors, standard overhead conductor and underground cable sizes have been selected. This results in minimum stock holdings and purchase prices, giving the users the least cost network.

- The standard conductor size that is equal to, or greater than that required for the reasonably foreseeable load, shall be used for each overhead network extension or reinforcement.
- The standard cable size that is equal to, or greater than that required for the horizon load, shall be used for each underground network extension or reinforcement.

Table 3-2: Cable and Conductor Sizes and Parameters

Cable	R [ohm/km]	X [ohm/km]	Rate [Amp]	11 kV	66 kV
16 mm^2 3C Cu	1.421	0.117	90	Yes	No
25 mm^2 3C Cu	0.870	0.117	100	Yes	No
25 mm^2 3C Al	1.441	0.117	80	Yes	No
35 mm^2 3C Cu	0.627	0.112	120	Yes	No
35 mm^2 3C Al	1.043	0.112	95	Yes	No
70 mm^2 3C Cu	0.321	0.101	185	Yes	No
95 mm^2 3C Cu	0.231	0.094	220	Yes	No
120 mm^2 3C Al	0.304	0.091	200	Yes	No
150 mm^2 3C Cu	0.149	0.089	280	Yes	No
150 mm^2 3C Al	0.248	0.089	225	Yes	No
150 mm^2 1C Al	0.248	0.089	315	No	Yes
185 mm^2 3C Cu	0.120	0.087	320	Yes	No
300 mm^2 1C Cu	0.074	0.082	495	No	Yes
800 mm^2 1C Al	0.049	0.129	697	No	Yes

3.4 Transformer Selection Criteria

In designing extensions to the network, ultimate load horizon planning shall be used to establish the network concept plan and the initial installation shall conform to that concept plan and use transformers that are appropriately sized.

The following standard transformer sizes will be considered.

Table 3-3: Standard Transformer Sizes

Description	Rate [MVA]	Vector Group	% Imp
66/11kV; 7.5 MVA	7.5	Dy11	8.1 %
66/11kV; 10 MVA	10	Dyn11	10.4 %
66/11kV; 15 MVA	15	Dyn11	9.7 %
66/11kV; 20 MVA	20	Dyn11	9.7 %

3.5 Financial Criteria

Expenditure on network extension or reinforcement is supported by rigorous financial analysis. Where appropriate, several alternative options are analysed, and the option with the most favourable NPV is selected.

Table 3-4: provides the financial parameters used by Stellenbosch.

Table 3-4: Financial Parameters

Parameter	Short -Term	Long-Term
Escalation rate (%)	8	10
Interest Rate on Capital (Discount Rate (%)	17	19
% Transmission Losses	2	2
% Distribution Losses	6	7
% Operation and Maintenance Cost	10	8
Average Power Factor	0.92	0.95
System Load Factor	0.7	0.65
Purchase Rate c/kWh	14	14
Average Selling Rate c/kWh	28	30
% Non-Payment	10	5