# MODERN NETWORK MASTER PLANNING METHODOLOGY, AN APPROACH TO ADDRESS NETWORK EXPANSION AND RENEWAL NEEDS DUE TO HIGHER ECONOMIC GROWTH AND SOCIO ECONOMIC NEEDS



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## 1 Abstract

This paper addresses Eskom's latest approach to long term investment in their Distribution business. An overview of international trends with respect to long term electricity network expansion planning is provided. The paper also summarises Eskom's latest planning methodology that incorporates some new trends key to the successful implementation of the Universal Access Plan recently launched by government. A new methodology document has been formally accepted as a guideline to be applied both within Eskom and by private firms contracted to do work for Eskom.

## 2 Introduction

"The objective of distribution planning is to provide an orderly and economic expansion of equipment and facilities to meet the utility's future electricity demand with an acceptable level of reliability." H. Lee Willis [Bibliography 7].

During April 2006 Eskom Management took the decision to undertake the Universal Access Plan (UAP), which will provide a comprehensive expansion plan aimed at accelerating the pace of Electrification to ensure 100% access to electricity in South Africa by 2012.

Other drivers for comprehensive electricity network planning include:

- the national Accelerated and Shared Growth Initiative for South Africa (ASGISA), a Government initiative aimed at achieving and sustaining a higher economic growth rate to ultimately halve poverty and unemployment by 2014
- the need to make additional capacity available due to rapid load growth
- the need for extensive refurbishment due to the age and performance of equipment and networks in certain areas
- the increasing lead times required for environmental assessments, servitude acquisition and procurement of equipment
- the findings of the CTAD audit on the network planning environment

In support of these initiatives, it will be necessary to ensure that adequate network capacity is available to supply the anticipated load demand. This will be done by conducting timeous Network Master Planning (NMP) and Network Development Planning (NDP) studies. This document summarises the standard approach to be adopted by all parties required to execute studies and compile NMP's and NDP's by and on behalf of Eskom Distribution.

Delivery of electric power is a capital-intensive business. The quantity of power needed its location and when it will be needed; all have to be planned well in advance. The network planner's task is to determine an orderly and economical expansion of

assets that meets Eskom's future electricity demand with an acceptable level of operability and reliability.

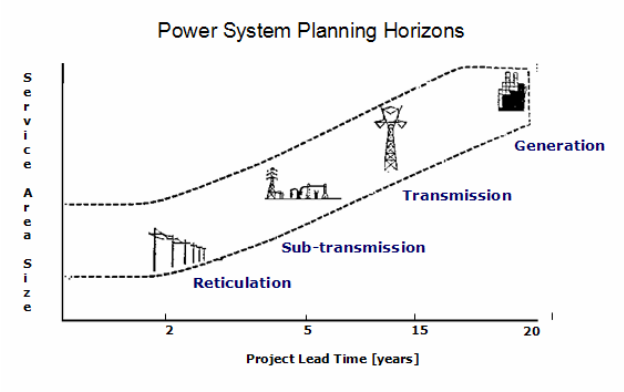


**Figure 1 : Typical Planning Horizons**

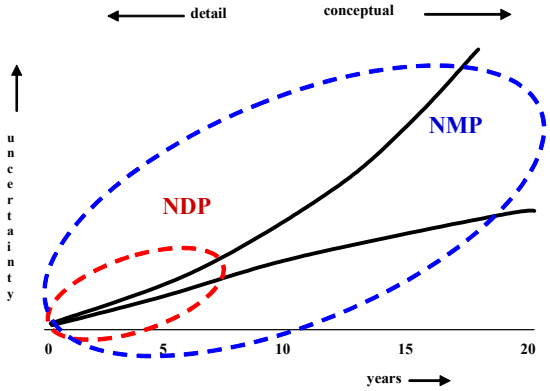


**Figure 2 : Time Perspective of NMP's vs. NDP's**

# 3 Planning Philosophy

## 3.1 Background of the Electricity Supply Industry (ESI)

The ESI has been through an evolutionary process since its inception approximately 100 years ago. Initially and for many years the business was seen as a high technology business, essential for economic growth and with a monopolistic characteristic. The default approach all over the world was to declare the business a natural monopoly to be owned and regulated by government.

Since the early 1970's this started to change.

These changes resulted in some changes in the ESI that can be categorised as follows:

- Regulated stable environment (pre-1970's)
- Regulated unstable environment (1970 – 1990)
- Regulated competitive environment (1990's onwards)

## 3.2 Global Planning Methodologies

### Traditional way of Planning

The traditional way of planning in the regulated stable environment was characterised by the following:

- The responsibilities and mandate of the utility was clear and was strictly controlled by government.
- The demand was predictable and a long-term estimate of demand growth was quite possible. Long term load forecasting was done with a reasonable degree of certainty.
- Resources to meet the forecasted demand could be identified far into the future and rather accurate assumptions could be made about capital expenditure on network infrastructure.
- Different network development alternatives could be compared with certainty and far into the future. Aspects such as equipment performance, system reliability and financial requirements could be quantified with an acceptable amount of certainty.
- Resource plans could be implemented where the risk was manageable.

The conventional approach to planning could easily optimise the cost of supply to the utility.

### Integrated Resource Planning (IRP)

The planning technique adopted in the regulated unstable environment between the 1970's and 1990's is called integrated resource planning and was characterised by the following:

- Utilities were still strongly regulated and the government still influenced management strongly.
- Load forecasting became more difficult and forecasting scenarios and stochastic techniques became more popular. Load forecasting had to recognise DSM initiatives and the effects of these on the demand trend line.
- Identifying generation resources included new alternatives such as purchasing power and DSM instead of building expensive new power plants.
- Analysing and evaluating all the system expansion alternatives were much more difficult as the required data increased exponentially and number of options increased significantly.

**Least Cost Planning (LCP)**

LCP also originated in the regulated unstable environment and is followed in the initial stages of market liberalisation. Basically the LCP process is similar to the IRP process as described above but with the following distinct optimisation criteria that seem to dominate:

- Minimise tariffs
- Minimise capital requirements
- Minimise kWh (energy) consumption
- Minimise losses

**Value Based Planning**

One major component missing in the planning processes discussed above is that the cost of unreliability of the power system or the unavailability of electricity supply to the customer is not factored into the total cost. Lately the concept of minimising total cost – to both the utility and to the customer is becoming the norm to select the most optimal network expansion alternative.

In order to calculate indices such as expected unserved energy (EUE) and loss of load probability (LOLP), it is necessary to employ probability techniques. Such indices can be used to compare network expansion alternatives.

Calculating probability indices for the power system calls for statistically based techniques such as Monte Carlo simulation and Contingency enumeration techniques. By using outage frequency and outage duration data for each component of the network, the probability of interruptions at each load point can be calculated.

Generally speaking value based techniques as described above are more suitable to assist with planning decisions in an environment where a greater amount of uncertainty exists as is common in liberalised whole sale markets. Electricity market reform is sweeping through the world and will most certainly influence the way utilities plan the development of their network – such influences will also have an influence on the South African electricity supply industry.

## 3.3 Planning Methodologies

A variety of planning approaches are in use worldwide. The success of specific methods depends on the type of system and planning environment.

In recent times, the success of planning methods has been largely influenced by the industry structure.

Generally speaking, planning is a decision-making process that can be broken down into five generic steps as shown in Table 1:

| Step | Activity | Notes |
|---|---|---|
| 1 | Identify the problem (includes gathering & analysing data) | Explicitly identify the range of application and its limits. Try to see the problem in terms of the goals and write it down. |
| 2 | Determine the goals | This tells you where you are aiming to go. What goals are to be achieved? Review the company's mission. What is to be minimised? |
| 3 | Identify the alternatives | What alternative solutions are available? This is a critical step. Never assume that one man can see all the alternatives. This should be a group session. |
| 4 | Evaluate the alternatives | Evaluate all the alternatives on a sound basis. |
| 5 | Select the best alternatives | Select the alternative that best satisfies the goals with respect to the problem |

**Table 1 : Planning Process**

# 4 Eskom's Planning Process

## 4.1 Overview

Figure 3 below illustrates a general process to conduct network planning and includes new features identified as necessary to stay in step with industry requirements. This process applies to both NMP as well as NDP. It is a holistic approach and addresses all aspects of Eskom Distributions network infrastructure planning, including the bulk supplies to support the national Electrification drive.

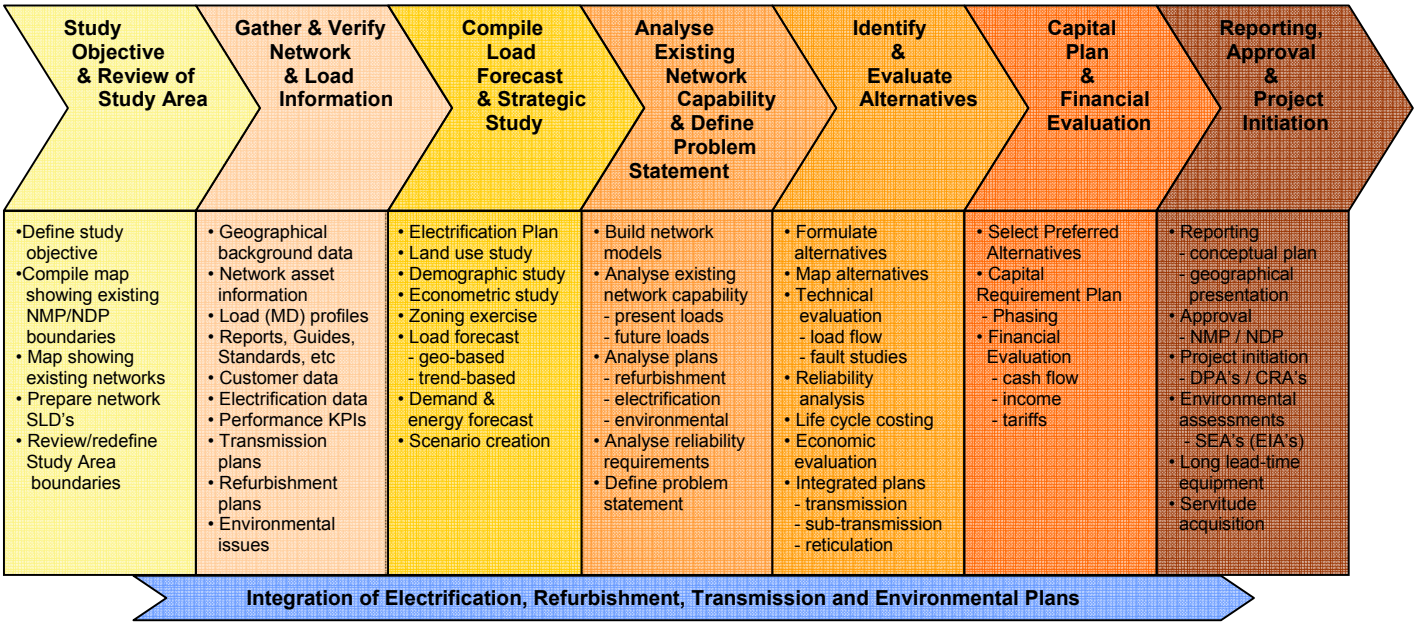


**Figure 3 : Eskom's Planning Process**

## 4.2 Planning Study Objective and Review of Study Area

This first step is of a universal nature and sets the stage for the particular study, be it a NMP or a NDP.

The network planner should allow for a clear definition of the primary and secondary objectives of the study, the confirmation of the study area, the recorded network needs and eventually the development of a problem statement.

Even though network study areas may previously have been defined, these should always be reviewed to adjust for network or organisational changes.

## 4.3 Gather and Verify Network and Load Information

During this task appropriate information to support the study should be obtained. Planners require a wide variety of raw data and processed information to compile an effective plan. This includes mostly network and load related data but should also investigate the availability of information related to the environment, as well as plans for other services such as transport and water.

Specific assessments are conducted by the responsible parties to provide comprehensive information to the planners for integration into either the NMP or NDP.

This task further entails a quality review and indexing of all obtained information. Field visits may be required to verify network layout and equipment data. Where load recordings are not available it may be necessary to launch an exercise to install special recorders to obtain the required loads.

## 4.4 Load Forecast and Strategic Study

The load forecast is a crucial input to both NMP's and NDP's. During this task a load forecast is developed that is based on regional demographic and historical load growth patterns, together with inputs such as Regional Electrification Plans, Local Economic Development (LED) Plans, Spatial Development Frameworks (SDF's) and other infrastructure development plans, often contained in Municipal Integrated Development Plans (IDP's).

It is important that the network planners have good insight into socio-economic developments by both public and private sector. Regional Planners & Economists should be utilised to conduct a strategic socio-economic study, which serves as an important input into the load forecast.

The load forecast for the NMP should provide a long-term strategic view on development and should

preferably be based on geo-spatial techniques, where the NDP load forecast will be based on actual registered needs, as well as short-term trending type load growth predictions.

The NDP load forecast should be used as input to the long-term load forecast. A full long-term geo-based load forecast can in turn be used to support the load forecast required for the NDP study, particularly in areas where significant Electrification growth is still anticipated.

## 4.5 Analyse Existing Network Capability and Problem Statement

This task should analyse all the data and information gathered during the previous steps or by others outside the planning process such as network operators.

A typical activity would be to develop adequate network models representing the sub-transmission and/or reticulation networks within the study area. Once these models have been confirmed to be an acceptable representation of the real world, future loads as projected by the load forecasting exercise can be applied to the network models and analysis studies can confirm shortcomings of the existing network.

The planner should then analyse and address the shortcomings in a coordinated manner and finally clearly define the network problems that have been identified.

## 4.6 Integration of Plans

The planner, in consultation with the relevant stakeholders, needs to integrate the various discipline specific plans into the overall network plan, either at a strategic level for a NMP or at a more detailed project level for a NDP.

These include the following plans:

- Electrification Plan
- Refurbishment Plans
- Transmission Plans
- Environmental Plan
- Reliability Plan

The Electrification section within Customer Services is responsible for compiling the detailed 5 year Electrification Plan. This is typically more relevant for a NDP study, but any long-term plans should be incorporated into a NMP study. The Plant Section is responsible for Primary Plant Refurbishment Planning, and Electricity Delivery is responsible for Control Plant Refurbishment Planning.

Integration of plans at all levels, including Transmission, Sub-transmission and Reticulation requires effective communication between stakeholders. Special emphasis is required for liaison with Transmission Expansion Planning, which is organisationally separated from Distribution Network Planning.

It is important to develop a common vision between all parties involved in network investment for the long-term development and renewal of the network over time.

## 4.7 Identify and Evaluate Alternatives

The objective of this task is to identify possible network solutions and to perform technical evaluations on these alternatives to ensure that the identified needs are addressed. Care should be taken to ensure that the level of technical capability of each network development alternative is more or less equal so that economic evaluation can be done fairly on each alternative.

Network analysis will adhere to the planning criteria as described in the Distribution Code and the Network Planning Guideline.

The economic evaluation should collectively assess all costing factors influencing the viability of the plan and should consider both the cost of new infrastructure as well as the life cycle cost of operating and maintaining the infrastructure.

## 4.8 Capital Plan and Financial Evaluation

The objective of this task is to refine and phase the capital cost of the preferred network development option.

As a minimum, the cost estimates should be based on the requirements for the following project business categories:

- Direct Customer
- Electrification
- Strengthening
- Refurbishment
- Reliability

It is sensible to do a financial analysis of the recommended network plan in order to confirm that the capital program will still meet cash flow and net income requirements of the strategic and business plans.

### 4.9 Reporting, Approval and Project Initiation

This task is of a general nature and touches on all the steps mentioned above. The task outlines the requirements for:

- Reporting, i.e. summary reports - the approach, findings and recommendations of the planning studies
- Approval of NMP's & NDP's in line with the Capital Investment Process and Network Asset Creation Value Chain.
- Project initiation, i.e. the release of projects into the business.

It includes the identification of long lead-time equipment, environmental assessments and servitude acquisition.

## 5 Conclusion

This document describes the main steps to be followed by network expansion planners involved in the long term development planning of Eskom's distribution networks. The document will be continuously reviewed and updated in order to stay in step with international best practice and also to address South Africa's needs for electrical energy. Aspects that will receive more attention in the near future are network reliability and economic evaluation. It is foreseen that these aspects will be incorporated into future updates of the methodology guideline.

The process may seem extensive but when compared to the amount of capital that will be spent on distribution network expansion and renewal it makes sense to follow a process as described as this will lower the risk of fruitless or non-optimal investment related expenditure.

## Abbreviations

| | |
|---|---|
| Alternative | One of a number of possible network plans being evaluated in a study |
| CAPEX | Capital Expenditure |
| Distribution | Eskom's Distribution Business |
| DSM | Demand Side Management |
| EDI | Electricity Distribution Industry |
| EIA | Environmental Impact Assessment |
| ESI | Electricity Supply Industry |
| IDP | Integrated Development Plan(ing) |
| IRP | Integrated Resource Planning |
| Load Zone | An area (typically homogeneous) defined for the purpose of analysis |
| LCP | Least Cost Planning |
| NDP | Network Development Plan(ning) |
| NMP | Network Master Plan(ning) |
| OPEX | Operating Expenditure |
| Reticulation System | Typically MV reticulation ≥1kV and ≤33kV, LV reticulation <1kV |
| Scenario | A postulated future event or sequence of possible events |
| Sub-transmission System | Typically 44kV and ≤132kV sub-transmission network |
| Transmission System | Typically 220kV – 765kV transmission network *(unless otherwise stated)* |

## Definitions

**"Distribution Networks":** All sub-transmission and reticulation electrical equipment (substations, lines and cables) owned and managed by Eskom's Distribution Group, from 132kV to LV (400/230V).

**Rural Network:** Network serving clustered or scattered structures, usually of low density, not served by well established infrastructure (i.e. roads, water, sewage, electricity).

**Urban Network:** Networks serving formally or informally built structures, usually of high density, serviced by well established infrastructure (i.e. roads, water, sewage, electricity).

**"Network Planning Process":** This is a process for assessing the ability of all network infrastructure to meet industry standards in respect of existing load, future load forecasts and reliability requirements.

**"Network Master Plan (NMP)":** A NMP consists of all the documentation that is produced during the network planning process where the focus is long-term and strategic. This documentation (i.e. software files and paper records) is required to support the Strategic Capital Plan and needed to review and revise the plan in the future.

**"Network Development Plan (NDP)":** A NDP consists of all the documentation that is produced during the network planning process where the focus is short to medium term in relation to the NMP. This documentation (i.e. software files and paper records) is required to support the 5-year Capital Business Plan and is needed to review and revise the plan in the future.

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