ESKOM DISTRIBUTION NETWORK PLANNING, A QUANTUM LEAP TO MEET INCREASED LOAD GROWTH AND IMPROVED NETWORK RELIABILITY

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1. Introduction

The challenges faced by Eskom Distribution Network Planning include the following:

- **Load growth**: Load growth has doubled as compared to the early 1990s. The number of network planners in Eskom has not increased proportional to the increase in load growth. Planners need to produce more, and need to be more effective.
- **Universal Access Planning (UAP):** The target to complete universal access to electricity by 2012 places an additional burden on planners to ensure that network infrastructure can support this additional load.
- **Reliability**: Incentive Based Regulation (IBR) and network performance targets necessitate that Eskom Distribution improves present network performance levels. A major step change in performance can only be achieved in conjunction with capital expenditure related to network redundancy and risk (reducing the number of customers and size of load at risk for network faults). Planners need to include reliability implications in network investment decisions.
  Note: Capital expenditure (primary plant planning and design) is a key aspect of network reliability improvement, but it is recognised that there are other business aspects such as systems and data collection methods, performance measurement and reporting standards, operation and maintenance practises, system automation, telecontrol, SCADA visibility and staff skills and training.
- **Data**: Planners, it is estimated, presently spend 80% of their time searching for data, and 20% of their time performing actual planning (load forecasting, need identification, alternative evaluation etc). Essential data needs to be validated and available for easy export to planning tools.
- **Staff turnover and skills**: The average experience of a network planner is typically less than 2 years. Staff turn over is high. Training systems are required to get new planners up to speed in the shortest time possible. The knowledge/plans of existing planners need to be available for easy reference by new planners. A career path needs to be created to retain experienced planners.
- **Distributed Generation (DG)**: The requirement to integrate co-generation and renewable generation requires a new set of skills as distribution planners traditionally do not have experience with the integration of generation.
- **Demand Side Management (DSM) and Local Integrated Resource Planning (LIRP):** DSM and LIRP require planners to assess both supply side and demand side alternatives to network constraints. Optimal solutions could involve DSM and/or utility owned distributed generation. Additional data, skills, models and tools are required for these assessments.

This paper describes present initiatives to address these challenges.

2. Strategy

As per figure 1, effective network planning builds on base data and systems:

- **Base Data**: Essential data for power system analysis, load forecasting and alternative evaluation.
- **Base Systems**: Software systems for power system analysis (load-flow and fault-level), load forecasting and need and project registers.

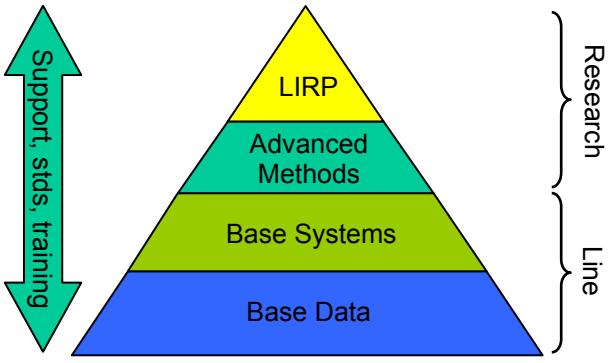

Figure 1: Network planning dependencies

Advanced Methods (probabilistic risk assessment and reliability analysis) and LIRP can only be implemented once base data and systems are in place.

Cutting across all of the above mentioned components is the need for support, standards, guidelines and training.

The strategy adopted by Eskom Distribution is as follows:

- Base data and systems are critical, and will typically be addressed via line projects and initiatives (short term within 18-24 months).
- Advanced systems and LIRP can only be effective once base data and system issues have been resolved, and will typically be addressed via research (medium term between 1 and 3 years).
- Supporting standards, guidelines and training material will be developed and rolled out in conjunction with the delivery of the components.
- Overall coordination is performed via the Technology Steering Committee of Distribution (TESCOD) Network Planning Study Committee.

3. Base Data

Present initiatives to address base data requirements include:

- **Data porting**: Eskom Distribution utilise the GE SmallWorld AM/FM GIS system as the primary data store for network information as required for network schematics, SCADA and power system analysis. HV and MV network location and connectivity is comprehensively captured in SmallWorld. However, certain attribute data required for power system analysis, such as conductor size, is incomplete and the accuracy of certain attributes is uncertain (in Smallworld) and captured accurately elsewhere. Much of this data is still contained in legacy systems and other databases such as Microstation as-built drawings, commissioning sheets and test sheets. A project has been initiated to port this data from these other systems and data sources into SmallWorld so that this data is readily available to the planner and can be exported to power system simulation software (see section 4.1).
- **Data processes**: The data porting project will also address the data processes, standards, commissioning sheets, test sheets etc to ensure that the HV and MV network data required by planners is captured in SmallWorld for future network additions and modifications.
- **Standard values**: For the purposes of network planning studies, standard (typical) values for equipment attributes can be utilised. Examples include typical impedances and losses for transformers, and per-unit length impedances (R, X and B values) for power lines and cables. A project is nearing completion for the implementation of standard value libraries in SmallWorld such that typical attribute values are available for attributes that have not been populated via data capture.
- **Statistical metering**: There is renewed focus on remotely downloaded statistical metering such that load profile data of active and reactive power (30 minute interval) is available for all major power transformers (typically at HV/HV and HV/MV substations), HV lines/cables and MV feeders.

The net objective of these projects is to provide planners with easy access to critical network and load data.

4. Base Systems

4.1 Power System Analysis

Eskom Distribution utilise ReticMaster and DigSilent PowerFactory for power system analysis. ReticMaster is used for basic studies on radial MV and LV networks. PowerFactory is used for sub-transmission network analysis and advanced simulation such as protection coordination, dynamic and transient analysis and harmonic studies.

Eskom's present SmallWorld system only supports a write-out of MV networks to ReticMaster. A project is underway to provide integration between SmallWorld and PowerFactory. PowerFactory will then be utilised for power system analysis on both MV and HV networks utilising the network data stored in SmallWorld. This facilitates advanced reliability studies (section 5). ReticMaster will continue to be used for all LV studies, and basic radial MV studies.

A Master Type Library (MTL) has been completed and provides a single source of type library (standard) values for systems including SmallWorld, ReticMaster and PowerFactory. This ensures that the same standard values (impedances etc) are utilised in all systems.

4.2 Project Need Register

The existing Project Need Register (PNR) in SmallWorld is being enhanced to provide planners with the following core functionality within the GIS:

- **Need register**: Needs are spatially located (GPS coordinates) so that interdependencies can be visualised.
- **Project register**: A project can have a number of alternatives, one of which is preferred. Each alternative can have jobs, network, costs, need dates, and other attributes associated with it. Alternatives can be written out to ReticMaster or PowerFactory for power system analysis. Projects and alternatives can be viewed spatially and are integrated with K2 project workflow and PowerOffice costing systems. Projects and alternatives can be linked to needs.

The PNR provides the planner with a GIS linked repository for needs, projects and alternatives such that this data is available throughout the enterprise and can be integrated with costing engines, workflow and power system simulation tools.

4.3 Geo-based load forecasting

Load forecasting is a critical component of network planning. Historically there has been no fully standardised system for load forecasting within Eskom Distribution Network Planning. Load forecasts were performed with differing methods in each Region. Based on a comprehensive user requirement analysis, the following key requirements have been identified:

- **Load hierarchy:** Loads must be specified at multiple levels (connected to LV, MV or HV networks) and summated such that the loading can be viewed at these multiple levels i.e. HV levels include loads connected at HV, MV and LV levels.
- **Load profiles**: Profile models are utilised to model load diversity and forecast both energy and demand.
- **Small area and land based**: Forecasts can be performed for user defined areas of land, and results reported and visualised in the SmallWorld GIS.
- **Forecast methods**: A range of different forecast methods are required including growth curves, s-curves, land use, trending, electrification ADMDs and user defined forecasts.
- **Libraries**: Libraries are utilised to provide standard values (load factor, power factor, load profile) for typical customer classes.
- **Scenarios**: Multiple load forecast scenarios are supported.
- **PSA link**: Load forecast results are linked to ReticMaster and PowerFactory so that manual population of forecasts within the simulation packages is not required.

A project is underway to source a commercial “off the shelf” solution providing an acceptable fit to the user requirements. In the interim a locally developed and supported Microsoft Excel based load forecasting tool, PowerGLF, will be utilised. Rollout is expected to be completed in the fourth quarter of 2007. A load forecasting guideline has been developed to support the PowerGLF rollout.

4.4 Project Evaluation Model

Historically Eskom Distribution Network Planning selected preferred alternatives based on capital cost considerations and compliance with minimum standards. Consideration of increased network reliability and higher cost of technical losses necessitate a new approach.

A Project Evaluation Model (PEM) is being developed to supplement the Financial Evaluation Model currently in use, with the intention to consider lifetime economic costs associated with capital, technical losses, reliability and operating and maintenance. This model will be utilised to select and motivate the best technical alternatives.

5. Reliability

Reliability considerations are being addressed via the following initiatives

- **Guideline**: A network planning reliability guideline has been compiled.
- **Training**: Reliability training forms one of the modules referred to in section 7.
- **Capex reliability link**: A project is establishing the capex solutions and costs to improve Eskom Distribution network performance. A key issue is an understanding of the scope and cost implication for the electrification UAP if a range of different performance targets are to be met.
- **Probabilistic reliability assessment**: Based on network models and equipment failure rates and repair times, the expected performance (SAIDI, SAIFI etc) of different network alternatives can be calculated. Based on Eskom Distribution requirements the probabilistic reliability assessment functionality

in PowerFactory has been enhanced. This functionality will be rolled out in a phased approach for HV and MV network analysis, and is dependent on the PowerFactory integration with SmallWorld (section 4.1).
- **Asset utilisation reporting**: The level of asset (network) utilisation and risk will be reported via KPIs, for example the number of un-firm HV/MV substations.

6. Standards and guidelines

Eskom Distribution Network Planning standards and guidelines are published via the Distribution Technology IARC website. Certain standards and guidelines require revision. New standards and guidelines have been identified for compilation.

The following standards and guidelines have recently been revised/completed:

- DGL 34-543 Network planning guideline for MV shunt capacitors.
- DGL 34-539 Network planning guideline for MV step-voltage regulators.
- DST 34-542 Distribution voltage regulation and apportionment limits.
- DISAGABL8 Planning guideline for MV underground cable systems.
- DGL 34-155 Network asset cost of supply methodology.
- DGL 34-431 Eskom methodology for network master plans and network development plans (this guideline is the subject of a companion paper entitled “Modern Network Master Planning Methodology - an approach to address network expansion and renewal needs due to higher economic growth and socio economic needs”).

The following standards and guidelines are in draft format pending formal approval:

- DGL 34-450 Network planning reliability guideline.
- BGL 34-335 Network planning philosophy.
- DGL 34-619 Network planning guideline for lines and cables.
- DGL 34-617 Network planning guideline for transformers.
- DGL 34-1284 Network planning guideline for geo-based load forecasting.

The standards and guidelines form the base material for the development of training material, as discussed in section 7.

7. Training and development

In order to facilitate the understanding and implementation of the standards and guidelines (section 6) training material needs to be developed and formally presented. The following training modules have been identified:

- Planning process and methodology.
- Network Planning philosophy.
- Reliability assessment.
- Electrification planning.
- Short and medium term load forecasting.
- Long term load forecasting.
- Project needs register.
- Power System Analysis.
- Project evaluation.
- Business planning.
- Power system protection.
- Transmission system planning.
- Project life cycle.
- Cost of Supply.
- Planning tools.
- General skills.

Three training modules are being targeted for completion in the 2007/8 financial year. Web based learning will form a core component of the training material, which will be formally accredited with ECSA.

As part of a broader skills retention program Eskom Distribution have commenced with an accelerated development program for specialists. The objective of the program is to accelerate the development of specialists within critical technical areas. Candidates within Network Planning have been short-listed for further evaluation. Successful candidates will be provided additional development opportunities and mentorship.

All of the standards and guidelines are available to the industry either free of charge or for a small administrative fee.

8. Management

Given the challenges faced with increased load growth, constrained networks, UAP and reliability improvement, Network Planning has received renewed focus from Eskom Distribution senior management. Examples include:

- **Industry Association Resource Centre (IARC) support**: A network planning sub-section has been formed to provide national technical support via three staff members.

- **National Network Integration Forum (NNIF)**: All Eskom Distribution and Transmission projects ≥ R35million are presented to the NNIF for technical assessment. The purpose of the forum is to ensure alignment and integration between Distribution, Transmission and Generation and compliance with technical, business, contractual, environmental, legal and regulatory criteria, such as compliance with the Transmission Grid Code and Distribution Network Code.
- **Master planning**: These are plans to determine geo-based loads for the next 20years with the corresponding HV and EHV network requirements. Due to internal resource constraints and the need for long term network master plans, Eskom Distribution has a strategy for the completion of master plans with the assistance of external consultants. A national panel of approved consultants (with the ability to produce master plans) has been established, and master planning network areas have been prioritised.
- **Funding**: The initiatives mentioned in this paper have a significant funding requirement, and the support of senior management and stakeholders in obtaining the funds is essential.

9. Conclusion

The successful completion and implementation of the initiatives summarised in this paper are intended to make a quantum step change in the quality and effectiveness of Eskom Distribution Network Planning and hopefully the EDI. This will result in well trained planners, with the data they require at their fingertips, utilising systems and tools that enhance their effectiveness and assist in the implementation of guidelines and standards. This will be critical in future IBR environments where network reliability targets are linked to financial incentives and penalties. The benefit is intended to be realised Industry wide, with IARC the main driver of skills development and knowledge transfer.

10. Acknowledgements

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