INTRODUCING RELIABILITY BASED DISTRIBUTION NETWORK PLANNING IN SOUTH AFRICA

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INTRODUCTION

This paper identifies challenges facing Eskom Distribution Planning in adopting reliability assessment within the broader planning methodology. Eskom has adopted the approach of Value Based Reliability Planning, the basic principles of which have been described by others, but implementation requires practical management decisions. Changes have implications for the relationship between the distributors of electricity and the Regulator.

BACKGROUND

Godfrey and Billinton [1] identified three key issues for the implementation of reliability planning:

- Plant reliability data
- Customer damage function data
- Reliability analysis software

To these have been added:

- Policy
- Business process
- Research
- Skills development

All of these aspects present challenges for distribution planners in South Africa because of a history of no or only limited reliability assessments. A lack of data on plant reliability and customer impact has forced planners to adopt deterministic approaches to network planning and, historically, redundancy-planning decisions have been based on simple rules [2, 3]. New requirements to assess the reliability constraints of reinforcement alternatives need quantitative reliability analysis as well as processes to use the results for decision-making.

POLICY

The policies of the National Electricity Regulator (NER) are a driving force shaping the Electricity Distribution Industry (EDI) through “deregulation” [4]. Government believes that operation of the industry will have to be constantly optimized to maximize the potential for adequate, reliable and low cost electricity to serve the people and industries of South Africa [4]. The present goal is to reduce the number of distributors from 241 Electricity Supply Authorities and Eskom to only six Regional Electricity Distributors.

One element of the restructuring of the EDI is a proposal by the NER to migrate from a Rate of Return to Performance Based Regulation mechanism to regulate electricity price increases. This will influence the reporting, planning, design and O&M philosophy surrounding distribution and transmission networks and service delivery to the end customer [5].

The NER’s change of approach is partly due to a lack of investment in electricity infrastructure and a decrease in maintenance and refurbishment by existing electricity supply authorities (Eskom and municipalities) [6]. At present, the NER only prescribes minimum quality of supply standards without any incentive schemes that encourage utilities to improve reliability levels [7]. Currently all strengthening projects are evaluated only on network and financial analysis and the tariff structure does not accommodate reliability investment support.

The policy change is a trigger for further development of Eskom’s strategic intent in respect of service delivery to customers - an approach to managing assets and commercial quality to achieve the overall objective defined by the stakeholders. The implication for Eskom of the changes in government and Regulator policy is a need to formally allocate operating expenses (OPEX) and capital expenses (CAPEX) to improve reliability of supply received by the customers [3]. The economic evaluation (net benefit to society) of reliability improvement projects requires a strategic decision to ensure financial viability of the EDI [5].

The Distribution Planning core objective will be to determine the reliability level (based on customer types and typical network classes) for which a Distribution Planner should plan a distribution network to improve reliability on a system level. The application of Value Based Reliability Planning (VBRP) principles clarify certain aspects required to make reliability-based decisions during the planning and design phase of strengthening project [8, 9]. The challenge that planners face is to balance utility cost of service, customer costs of outages and the risk of events that impose high costs on both customers and the electric utility [1].

BUSINESS PROCESSES

Increased regulatory pressure to improve efficiency within utilities requires enhanced outage reporting systems that also include equipment (primary and control) reliability failure data. The main need is to identify relevant data fields, requiring a change of data architecture. New fields include the reasons for failure, and the condition and performance of the equipment that influences continuity of supply experienced by the end user.
Investment decisions for reliability improvement strategies should be divided into short (1 to +/- 2 years), medium (2 to +/- 3 years) and long term (> 3 years) programs. These periods will focus the direction of the business for CAPEX and OPEX reliability decisions. The major influence is the regulating period proposed by the NER [3].

The allocation of reliability improvement projects within the different investment decision periods assists the process of allocation of OPEX and CAPEX. At this stage OPEX needs to be the focus in the short term to improve reliability. Cutting the OPEX budget will worsen the situation currently experienced. Increasing the OPEX budget as indicated by the key reliability projects (increase live work, vegetation management, woodpole inspection/replacement and network visibility/SCADA) and reviewing resource allocations within the Field Services are crucial for maintaining and improving reliability of the networks.

The application of VBRP will clarify aspects required to make reliability-based decisions during the planning and design phase of a strengthening project [8, 9]. VBRP analysis is an approach to the evaluation of Eskom Distribution investments that quantifies in economic terms the effects of different strengthening alternatives on reliability. VBRP provides the planner the economic worth of reliability by calculating the benefits of improving the quality of the service for the good of society. To achieve this goal, a social cost-benefit analysis is needed to evaluate the inherent trade-off between the increase in the capital costs required to achieve a higher level of reliability and the corresponding decline in outage costs.

**DATA**

**Plant Reliability Database**

Currently only technical reliability and quality of supply key performance indicators (KPIs) are reported to Eskom corporate management. No equipment reliability KPIs are reported and the long term plan is to report at high level on the equipment reliability for the Distribution business. At this stage only major equipment failure is investigated and captured on the performance database. The integration and consolidation of primary and control plant performance measures are being investigated. Thus, technical reliability will integrate network performance, equipment reliability and control plant performance. This will provide a national standard and a meaningful set of technical reliability indicators for the Distribution business.

Useful statistical information describing the associations between different make, type, aging and performance of equipment will provide numerous benefits to manage the existing assets. The establishment of equipment reliability KPIs will enable the Eskom Distribution to participate in international equipment reliability benchmark exercises. An appropriate linkage between equipment failure and equipment characteristic (based on external factors and operating & maintenance philosophy) will be established with the implementation of the equipment reliability database [10]. The extension of equipment useful life and reduction of probability of failure is influence by the O&M philosophy adopted within each utility. Improvement in quality and quantity of the information captured will improve confidence in the reliability analysis.

Eskom Distribution has not yet collected equipment reliability data due to a lack of a suitable reliability methodology. The implementation of the new database structure for equipment and control plant reliability data will take years before fully implemented and populated. Thus, a lack of reliability data and tools can and has prevented the implementation of reliability assessment techniques (including Reliability Centred Maintenance and VBRP). Reliability data collection and assessment will evolve together and therefore the process will be iterative [1]. Currently numerous international publications and surveys have used “typical” equipment reliability figures. The reliability predictive techniques can make use of reliability failure rates for different components based on international norms.

**Customer Damage Function Database**

Eskom Distribution has initiated research to review existing customer survey questionnaires [11, 12] used by different utilities to determine the costs associated with interruptions to different types of customers. At this stage Eskom only measures the average customer cost associated with the energy not supplied by customer survey. The customer survey is conducted (very small sample size) by transmission planning. It does not consider the effects of damage associated with the duration of interruptions.

South Africa is sparsely populated and electrification of deep rural communities presents an unusual challenge for the EDI. It is very difficult to factor aspects such as political weight associated with the customer damage function for electrification communities. Electrification only caters for low consumption so the design requirement is based on the bare minimum capacity to electrify the communities. Improving the reliability for these communities will be costly relative to the amount of revenue obtained. For this reason, a combination of minimum standard criteria and incentive base regulatory mechanism is foreseen as needed to prevent these from communities receiving less reliable supply.

An internal working group has been established to define the steps to be taken for the compilation and execution of the customer survey questionnaire to determine the customer damage function for Eskom Distribution customers. Some factors being examined include:

**Categorisation.** The customers are sorted into categories aligned with the tariff structure. Alternative categories (or characteristic economic segmentation) may be considered in future, when more data has been collected, but at this stage
tariffs provide the best clustering of customers.

Stratification. The parameters being used to stratify the sample size include size of customer, rural/urban location, tariff classes, climatic region and, possibly, voltage level.

Questionnaire. Several core survey questionnaires were reviewed to compile an Eskom Distribution revised questionnaire. They included questionnaires used in USA, Canada and Australia, as well as a questionnaire used by Eskom Transmission. Separate questionnaires will be used for rural and urban customers due to the substantially different network and associated characteristics. Different scenarios will assess the seasonal and time of week influences on the customer interruption cost associated with the interruption duration. Variant questionnaires (with small differences of the details in the basic questions) and fuzzy logic analysis will be used to reduce the length of the questionnaire to acceptable length.

Delivery Sample. A pilot survey is expected, assessing a small sample of customers, including some customers already being monitored under the national load research programme. The pilot survey will enable the working group to test and improve the variant questionnaires and to identify any problems associated with the survey questions.

Prioritisation. It is impractical to complete all the data collection immediately. Priorities need to be assigned to customer groups and regions. As the generally applicable information becomes available, more detailed analysis can be made in the areas where it will be most effective in changing decision-making. Therefore, the survey should be considered as a continuous process.

Methodology. It has been stated that it is necessary to separate the utility from the survey by using independent market research companies. The main problem that arises is that it decouples the customer data from the network-based quality of supply information available to the utility. Additional information is available where the utility carries out the questionnaire analysis. Also, the utilisation of more than one survey technique allows evaluation of the effectiveness of the different techniques for subsequent larger samples.

RESEARCH

Published research does not provide “plug and play” solutions for utilities. The valuable lessons learned from published work need be inspected and criticized before reproducing the work within Eskom Distribution. Significant differences exist between the community structures, network technologies, economic environments, utility operating practices and legal systems in different countries, and the effects of these and similar variations need to be considered.

Eskom Research and Strategy has established the Distribution Reliability Research Steering Committee to ensure that research projects are coordinated between the various research groups and the line functions. The steering committee has defined certain key focus areas to approach the reliability drive in a holistic manner, including adequate consideration of external stakeholders concerns, distribution planning, maintenance, operations, network performance monitoring, energy trading, system design, asset management and skills development.

The research portfolio will attempt to identify and reduce the assumptions or obstacles (equipment reliability data, methodology, tariff influence, reliability assessment tool, customer damage function, etc) that hinder the incorporation of reliability assessment in strengthening alternatives for a planning project. Already, numerous short, medium and long-term research topics have been identified to investigate the impact of the implementation of VBRP principles on the EDI. They also provide opportunities to work closely with universities.

The Distribution Reliability Research Steering Committee will also evaluate the implementation plan for incorporating reliability assessment into the planning phase of strengthening projects.

COMPUTER SYSTEMS AND SOFTWARE

Currently no reliability prediction analysis software is utilised to evaluate reliability improvement in different strengthening alternatives for sub-transmission and distribution networks. Presently Eskom Distribution is evaluating a Reliability Assessment Tool (RAT) to perform reliability analysis.

Eskom compiled a User Requirement Specification (URS) document, which is used as a foundation for the evaluation of the existing network analysis software packages with RAT capability. The URS was followed with training and a workshop session to compile a functional gap analysis. The session was important to determine whether the existing software capacity aligns with the URS compiled by Eskom. In this process, it was imperative to compare the RAT with model IEEE reliability test systems to ensure that algorithms are correct [11].

Existing business systems and processes probably need to be changed to support the RAT’s input requirements. Sensitivity or Monte Carlo analysis tests the effects of uncertainty associated with the input data (equipment reliability data) and is imperative to improve the confidence in the results [11]. The data obtained from published literature can be used to facilitate the comparative analyses between different strengthening or design alternatives within the planning and design phase of a project [1].

Several reliability assessment techniques have emerged and numerous assessment tools (RATs) are available to assess the reliability constraints on networks. Management’s confidence
in the results obtained by the various tools requires understanding the engine behind the graphical user interface. A major research effort is needed in the business system data architecture changes required to meet the input requirements for the RAT.

SKILLS DEVELOPMENT

It is crucial to train existing personnel on the new techniques and process changes required to support the implementation process. An internal accredited course that is externally moderated may be prepared to review technical content and ensure correct teaching principles. A modular approach has been recommended, using multi-media material to encourage self development.

In establishing the training courses, interaction with educational institution such as universities will be encouraged, to reinforce the correct application of fundamental theory. Academic institutions are expected to incorporate reliability assessment techniques within the broader syllabus.

CONCLUSION

The change from traditional planning methods to the inclusion of reliability analysis in the broader planning methodology involves difficult initial trade-offs. The proposed implementation with international plant reliability data and average customer damage function will enable Eskom to evaluate the impact of the methodology on the business, while collecting relevant local data.

Technology enhancement through research is an important input criterion to the policymaking process. Many of the initiatives (including research, resources and funding) are expected to become partnerships between the Regulator and distributors. Guidelines prescribing the planning limitation for strengthening distribution networks will probably take into consideration improving reliability levels. These efforts will guide the way forward for the EDI with respect to capital investment in infrastructure and finding the balance between reliability and customer worth.

However, the uncertainties stand only as a challenge to the EDI to improve the data (such as plant failure rates and customer costs) and techniques to evaluate reliability constraints and to optimize OPEX and CAPEX. The most difficult obstacle may be a management perception that the reliability initiatives will be quick fix solution and that the reliability improvement projects and initiatives could be implemented yesterday. These initiatives will require time to mature understanding of the impact and benefit achieved by the different efforts within the different business functions to meet national interest. A major influence will be business process changes required to support the implementation of reliability assessment techniques.

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REFERENCES


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