Skills Development for Network Planner's in Eskom's Distribution Business

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Abstract

The current skills base in Eskom's Distribution Network Planning environment is strained with high staff turnover and the lack of sufficient training programs for the network planners. The only form of training that is available is scattered classroom based training which makes it difficult for the staff to attend development courses in their quest to "Sharpen the Saw"; the Seven Habit of Highly Effective People, Steven Covey.

The gap in the ability to deliver effective on demand training has introduced the need to develop a “Blended Learning” solution. Blended Learning incorporates the most efficient and effective combinations of learning delivery methods. From of traditional classroom based learning to the modern eLearning or web based learning that can be accessed via a Learning Management System (LMS) such as the MyLearning system currently in use by Eskom. The intention of the online training is to skill the newly appointed network planning engineers to a competence level required to effectively perform their job function.

E-Learning is a relatively new concept in engineering within the Eskom Distribution Network Planning environment. The system allows an individual, "the prospective learner" to log onto the LMS and to either self enrol or are pre-enrolled for a specific course within the distribution network planning environment.

In order to assist the learner and to create a logical flow to the courseware, from an instructional design perspective, the course is modularized to enable learning in modular sections. The training program covers the contents of each of the standards and guidelines for Network Planning under the Technical Steering Committee of Distribution (TESCOD).

At present the Network Master Planning and Network Development Planning methodology course has been developed. In future a set of 20 modules will form part of the network planning training program that will be available to all Eskom Staff. Access to these modules can be made available to the members of the AMEU.

This paper provides an overview of the Network Planning modules to be developed on MyLearning.

Key words: E-Learning, Network Planning, Collaborative learning, Distance e-learning, Learning Management Systems, Knowledge Management systems.

1. Introduction

The Industry Association Resource Centre (IARC), positioned under the Sustainability and Innovation Department within the Corporate Services Division of Eskom Holdings Limited is committed to supporting the Eskom – Distribution Division and the Electrical Supply Industry at large. This is made possible by a team of industry experienced resources that collectively have myriad years of experience, knowledge and skill to provide technology support and development to the distribution industry.

The network planning technology development team, located in the Power Plant section of IARC is responsible for technology development and standardization of the more than one-hundred and twenty (120) Eskom Distribution network planners

spread over the geographical boundaries of the Republic of South Africa.

The six Eskom Distribution network planning regions are responsible for the strategic development of the distribution network to ensure its sustainability into the future, from both an electric demand and network reliability perspective.

The Regional Distribution Network Planning sections' have experienced high staff turnover that has highlighted the need for concentrated distribution industry training in a multi-delivery approach. This need has led to the development of a network planning training framework that identifies the principles of the training which in turn initiated a research funded project to role out technical training for the distribution network planners on an e-learning platform.

2. Benefits of e-Learning

In order to ensure ongoing development of Eskom's human capacity in the network planning environment, a three tiered learning approach was adopted which enforces e-leaning with the virtual class room and the facilitated training that completes the blended learning environment. This approach is represented in figure 1, below:

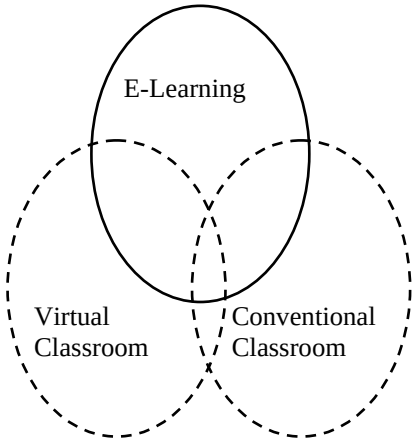

Figure 1: The Blended Learning Solution

The development of the Distribution Technical Training Program for the Network Planning Engineers is designed to address:

- The current skills gap
- High Staff turnover
- Succession planning
- Skills & Knowledge Transfer
- Skills Building and Capacity Planning
- Demand for higher skilled staff
- Need for Standardization of training

3. The Training Framework

The Training Framework was commissioned under the guidance of the Planning Study Committee, chaired by Dr Clinton Carter-Brown. The Framework identifies twelve (12) major learning areas, namely: Distribution Engineering (Basic Principles), Distribution Planning, Load Forecasting, Distribution Economics, Transformers, Lines, Cables, Power Systems, Distributed Generation, Power Quality, Reliability and Protection.

The Planning Study Committee (PSC) is constituted by working group leaders, national advisors and corporate consultants. The PSC overseas and directs the working groups on the activities and deliverables required to support and develop technology enhancements within the distribution planning environment.

The working groups are responsible for the following functional areas within network planning, namely: Network Master Planning, Geo Based Load Forecasting, Distribution Philosophy, Network Reliability, Financial and Economic Evaluations, Cost of Supply, Planning Tools and Integration, Business Planning Model, Electrification, Project Prioritization, Asset Utilization, Embedded Generation, Planning Training and Standards.

The working groups are tasked with developing national guidelines and standards to support the above mentioned functional disciplines within network planning. The core outputs of the initial training development will concentrate on the guidelines and standards that will be developed on the e-learning platform.

The aim is to develop e-learning courses for each of the Network Planning standards and guidelines as described in the following section. A high level overview of each of the standards and guidelines are provided to give the reader insight into the content of each of the e-learning courses.

4. Distribution Technical Training Program

4.1 Network Master Planning and Network Development Planning Methodology

The Eskom Distribution methodology for Network Master Plans and Network Development Plans [1], details the process and data sources that are required when compiling Network Master Plans and Network Development Plans. This process is particularly important in light of the requirements of the distribution Network Grid code and the South African Grid Code. Network planners are required to use this process as a reference to ensure that all required information and subject matter is documented. The main activities of the process are summarized as follows:

- Study Objective & Review of Study Area
- Gather & Verify Network & Load Information
- Compile Load Forecast & Strategic Study
- Analyze Existing Network Capability & Define Problem Statement
- Identify & Evaluate Alternatives
- Capital Plan & Financial Evaluation
- Reporting, Approval & Project Initiation

4.2 Network Planning Reliability Guideline

The Network Planning Reliability Guideline [2] recommends network planning criteria to improve the overall network reliability as influenced by Network Planning decisions. The guideline focuses on HV and MV network planning performance areas such as flexibility, reliability, availability and network capacity to improve the medium to long term continuity of supply of the Eskom Distribution network. It recommends minimum network criteria for Network Planners thereby providing trigger points for investigating alternatives to reduce customer exposure to network faults. This in turn is aimed at reducing the duration of network faults and thereby improving the performance of the network.

4.3 Medium Voltage Underground Cables for Planners

The Network Planning Guideline for Medium Voltage Underground Cable Systems [3] has been prepared in order to introduce a guideline for the planning of medium voltage underground cable networks in Eskom Distribution – with specific focus to the secondary distribution network configuration. Due to the relatively high costs of installing underground cable systems and the expected improved network performance in comparison to overhead lines, it is essential that the growth and expansion of cable networks is planned and implemented based upon a defined and consistent philosophy. Medium voltage networks constitute up to 25% of the investment cost in the supply of power to customers in Eskom. Growth of underground cable networks on an ad hoc basis results in networks that are complex and sometimes over or under-designed. This results in higher probabilities of equipment and system related failures than is necessary – compromising the customer quality of supply.

The guideline for medium voltage underground cable systems assists Network Planners in optimising both the long-term capital expenditure and the overall network performance – in support of customer quality of supply, network connectivity and operational flexibility.

4.4 Geo Based Load Forecasting

The Geo-Based Load Forecast Guideline [4] provides insight into important principles and theory underlying a load forecast and provides a practical perspective on application within the Eskom environment. The main concepts of geo-based load forecasting are as follows:

- The Network Planning Process
- What is Geo-Based Load Forecasting
- Important Load Forecasting Concepts/Issues
- Load Forecast Methods
- Load Hierarchy Summation

4.5 Network Planning Guideline for Lines and Cables

The Network Planning Guideline for Lines and Cables [5] provides the Eskom Distribution Network Planner with a basic understanding of the theory and practical application, such that lines/cables can be modelled in power system analysis software (specifically Reticmaster and Power Factory) and new line/cable sizes can be selected based on minimum requirements and lifetime costs.

The location and size of future MV and HV overhead lines and buried cables is an important component of Distribution Network Planning. Network Planners need to understand the basic theory and relevant

Eskom Distribution standards and specifications relating to lines and cables. They also require guidance on the modelling of lines/cables in network simulation software. Network Planners need to be able to select line/cable sizes such that minimum requirements (thermal limits, fault level rating and voltage drop) are met whilst also minimising capital cost and the lifetime cost of technical load losses.

4.6 Medium Voltage Step Voltage Regulators

The Medium Voltage Step Voltage Regulators guideline [6] provides Distribution Network Planners with the theory and tools to model and evaluate MV step voltage regulators. The guideline contains information on how voltage regulators operate, how they should be modelled in power system simulation tools, when they should be employed and how they respond to factors such as load steps, motor starting and load unbalance. Via application of the guideline, distribution networks containing voltage regulators can be accurately and easily modelled in a uniform approach ensuring accuracy and consistency. The guideline contains six sections, viz.:

- Theory of voltage regulation and voltage regulator operation
- Step-voltage regulator technical information
- Considerations when evaluating regulators in networks
- Specifying voltage regulators
- Modelling voltage regulators in Reticmaster (including demo and example cases)
- Modelling voltage regulators in DigSilent Power-Factory (including demo and example cases)

4.7 Network Planning Guideline for MV Shunt Capacitors

The Network Planning Guideline for MV Shunt Capacitors [7] covers both the theory of operation and practical modelling of MV shunt capacitor banks, such that shunt compensation can be evaluated as part of the overall distribution planning, design and optimisation process.

The guideline is focused on the application of MV shunt capacitor banks to overhead MV distribution networks i.e. shunt capacitors installed along overhead MV feeders, and not in sub-transmission substations. Many of the principles are however also applicable to sub-transmission reactive power compensation.

4.8 Network Planning Guideline for Transformers

The Network Planning Guideline for Transformers [8] provides the Eskom Distribution Network Planner with a basic understanding of the theory and practical application, such that power transformers (HV/HV, HV/MV, MV/MV and MV/LV) can be modelled in power system analysis software (specifically Reticmaster and Power-Factory) and new transformers sizes can be selected based on minimum requirements and redundancy criteria.

The location and size of power transformers is an important component of Distribution Network Planning. Network Planners need to understand the basic theory and relevant Eskom Distribution standards and specifications relating to power transformers. They also require guidance on the modelling of transformers in network simulation software. Network Planners need to be able to select transformers such that minimum requirements (thermal limits, fault level ratings and vector group compatibility) are met whilst also ensuring the redundancy requirements are complied with.

4.9 Distribution Planning Standard

The Distribution Planning Standard [9] is aimed at equipping the network planner with information required to understand the network planning philosophy within the Eskom Distribution environment. The document consists of three sections that describe the Network Planning Philosophy, external regulatory standards and the Internal IARC standards& guidelines**.** The external regulatory standards act as drivers “pushing” the network planners to ensure technical and financial governance. While the internal drivers such as the IARC planning guidelines and standards, “pull” the network planner towards a standardized approach when dealing with the capital investment and the expansion of the Distribution Power System.

The planning criteria section in the document assists in the interpretation of the technical requirements when expanding the power system. The impact of new customers on the existing network and the associated power quality requirements is dealt with in the Quality of Supply section.

The application guide section references the planning standards and guidelines that will assist the network

planner with the understanding and implementation of the Network Planning Philosophy and ensure compliance with regulatory requirements.

The concluding section of this standard summarizes in the annexure the ***South African Grid Code*** and the ***Distribution Code*** to enable an understanding of two of the external policies that influence the decisions and the thinking of the Distribution Network Planner.

4.10 Network Planning Guideline for Financial Evaluation of Projects

The Network Planning guideline for financial evaluation of capital projects [10], documents parameters and process of using the financial evaluation model (FEM) application. The FEM is used to determine the financial viability of projects considering the capital, operating & maintenance costs and sales revenue.

4.11 Network Planning Guideline for Voltage Technology & phasing

The Network Planning Guideline for Voltage Technology and Phasing [11] covers the theory, standards, software modelling and selection of MV and LV network technologies for Eskom Distribution Network Planning. The technologies include three phase star (4-wire), three phase delta (3-wire), phase to phase, Single Wire Earth Return, single phase and dual phase.

The guideline provides the Eskom Distribution Network Planner with a basic understanding of the theory and practical application, such that both balanced and unbalanced distribution (MV and LV) networks can be modelled in power system analysis software (specifically Reticmaster and Power Factory) and that appropriate voltage levels and technologies are selected for new networks and network upgrades.

4.12 Network Planning Guideline for Electrical Motors

Network Planning Guideline for Electrical Motors [12] covers potential problems that may occur when connecting large electrical motors to an electrical network, while also addressing application considerations required to model electric motor starting in a load flow simulation package. The main topics discussed are as follows:

- Basic theory of induction machines
- Motor starting
- Power Quality
- Application guideline
- Modelling Motors in PSA Software
- Worked examples

4.13 Network Planning Guideline for Business Planning

The distribution business plan is the outcome of a Development Plan Approval / Network Development Plan that has been filtered through the project prioritization model. All projects identified within a 5 year period are identified and updated annually. The business plan is required to inform the distribution business of the required funding for future investment in order to develop the distribution power system. This plan is used by the Divisional Capital Program and the tariff planning in line with the cost of supply methodology to provide for future funding.

4.14 Network Planning Guideline for Project Prioritization

A project prioritization model has been developed and assists the network planner with the ranking of projects in order of highest priority based on certain distribution investment criteria. This model is implemented as a MS excel tool.

The Network Planning Guideline for Project Prioritization aims to document the national and regionally accepted approaches to support the prioritization of projects, providing direction principles to be used when ranking projects for the various business categories of capital expenditure.

4.15 Network Planning guideline for Embedded Generation

Network Planning guidelines for Embedded Generation (EG) connection to the Distribution Network

- Fundamental System Studies: The guideline documents basic theory, effects of EG on the networks, core issues for power flow and systems studies and connection schemes of EG to the distribution networks.
- Steady State Case Studies: The guideline illustrates the application of case studies for the Embedded Generation planning guideline.
- Advanced System Studies: The guideline will cover complex system studies for inter-connecting

embedded generators to the Eskom Distribution network.

- Embedded Generation Information: The guideline will document a master type library containing generic generator information needed by network planners to model embedded generators for power systems simulation studies.

4.16 Network Asset Cost of Supply Methodology

The network asset cost of supply methodology [16] describes the methodology for performing the Regional Cost of Supply exercise to determine the Reduced Network Diagram (RND) and Network Replacement Cost Table (NRCT) that form an input into Regional tariff design.

4.17 Distribution voltage regulation and apportionment limits

This standard [17] provides maximum voltage variations and voltage drops in high-voltage (HV), medium-voltage (MV) and low-voltage (LV) networks, so that these limits can be used for the planning, design, operation and optimisation of Eskom's distribution networks. It includes transformer voltage control and tap settings.

4.18 Network Planning Guideline for Electrification Plans

The guideline [18] focuses on the process of information between Electrification Planning and Network Planning. The process involved is initiated by a demand side plan for electrification connection. The demand side plan is transformed into a supply side plan and results in an Electrification plan through the release of a Development Plan Approval (DPA) and a Concept Release Approval (CRA). In order to secure an understanding of this process, the Network Planner and Electrification Planner must have a thorough understanding of the Electrification Process as documented as part of the Capital Investment Process in the Distribution business.

5. Development of the e-learning material

The above standards and guidelines will form the basis of the e-learning courses and represents the suite of training that will be available to the network planning engineer in order to accelerate their development.

The process of converting the base line material represented above into e-learning material is best described by the Analysis, Design, Development, Implementation and Evaluation Model (ADDIE) model.

5.1 Analysis phase

The analysis phase seeks to study the contents of the learning material; propose a learning solution or a curriculum; proposes the type of assessment required to evaluate the learners understanding of the subject; evaluate the target audience in terms of demographics e.g. language and academic background. This phase identifies the stakeholders and subject matter experts and must highlight the risks associated with factors that could possibly delay the delivery of the training initiative.

5.2 Design phase

The design phase relates to the technical structure, sequence and flow of the content. This phase ensures that the organisational structure of the course is segmented into bite size learning sections, not to present cognitive overload of information. This phase is also concerned with the type and delivery of the material to ensure that voice and band width is sufficient from an information technology infrastructure perspective. All aspects of the course are dealt with from the look and feel of the information to the presentation of help functions and course navigation. The colour of the interfaces, sequencing of text and pages, images & animation and interactivity is concentrated on during this phase. The aim is ultimately to ensure that information is presented and displayed in a skilful way to ensure that learning takes place.

Designing the course involves the use of assessments in order to assess or determine if understanding and Learning has actually taken place by the learner. As part of the MyLearning environment, there is a specialised assessment engine or tool known as QuestionMark Perception (QMP), whose sole purpose is to design and deploy assessments, questionnaires and surveys related to the course. In this way the system can evaluate the correctness of an answer and provide encouragement where the answer is not correct and a success status when the answer is correct. This

tool can also be used to conduct statistical analysis around a specific question. In this way, valuable information can be extracted and this can influence the training content through course enhancements. If a need arises for specialised interventions such as workshops or seminars to handle specific areas where learners have not done well, then the QMP tool can provide information to support these initiatives.

Other more interactive methods of stimulating learning can be achieved by the use of a mentor or coach that assists the learner in activities that are used as "gateways" within the program prior to proceeding to the next level of learning.

The design phase, also known as instruction design is a critical output as it contains the blue print for the course. Approval by the subject matter expert (sme) is critical in this phase to avoid the "sleeping sme syndrome".

5.3 Development phase

The development phase is purely an operation stage that follows the instructional design laid out in the design stage. This phase uses a sequence of story boards to represent each and every transition of the e-learning content. It is at this stage that images, animations, illustrations; assessments are drawn, written and compiled as laid out by the Instructional Designer during the design phase. It is at this phase where each module and component is put together to create the actual course.

5.4 Implementation phase

The implementation phase focuses on the deployment strategy for the course. During this phase, emphasis is placed on the learner and manager. The common question asked is “How will the learner, mentor and manager access and experience this?” There are multiple ways to deploy the solution and most appropriate route needs to be chosen. This phase also looks at the migration of the training course and program from the test environment to the production environment. This phase supports the sign off of both the system and content that was approved by the subject matter experts during the design stage. The working groups have agreed to allow the Distribution Technical Training program to undergo two testing levels before it is rolled out to the distribution planning fraternity. The first user test comprises of the working group evaluating the live course and the second user test ensures engagement of all the Network Planning Senior Engineers to evaluate the course. This two pronged approach is aimed at ensuring that the working group members, who will become the regional mentors and the senior engineers, who will serve as first line subject matter support are given an opportunity to evaluate the course contents and system before the network planning fraternity is scheduled on the training.

5.5 Evaluation phase

The evaluation phase seeks to evaluate the effectiveness of the training. This is achieved through online questions that are posed to the learner, whereby feedback is tracked and banked for future improvement. It is at this stage that progress and performance reports are draw. These reports relate to both learners as well as the course owner. This phase assists in determining what change management initiatives needs to be triggered to assist learners as they take up the course. Being a new concept, learner support and encouragement is critical.

6. Conclusion

At present a number of modules are under development with a plan to develop 20 modules over a three year period. The program is focused on Eskom Distribution; however, the material can also be made available to the Electricity Delivery Industry.

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♣ Document in Draft