SMART GRID TECHNOLOGY DEPLOYMENT AND IMPACT ASSESSMENT AT eTHEKWINI ELECTRICITY

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Mini-Thesis submitted in compliance with the requirements for the fulfillment of completion of a Masters Degree in Energy and Power Systems in the Department of Electrical Engineering of the University of Kwazulu Natal

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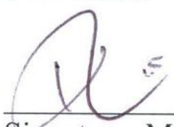
Supervised by Dr. I E Davisdon

Declarations

Declaration by Student:
I, Mr. Virendra Ramprith, do hereby declare that I make this submission as a requirement for the fulfillment of completion of a Masters Degree in Energy and Power Systems in the Department of Electrical Engineering at the University of Kwazulu Natal. I have not previously submitted this mini-thesis for the award of any other degree at any tertiary institution. I further declare that this is my original work and all relevant references have been made.



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Declaration by Supervisor:
I, Dr Innocent E Davidson, Director and Research Coordinator, at the Eskom Centre of Excellence in HVDC Engineering, University of Kwa-Zulu Natal, do hereby declare that I was the supervisor of this mini-thesis and deem it fit for submission for the award of a Masters Degree in Energy Power Systems.

Signature: Dr Innocent E Davidson

Date: 5th February 2015

Dedication

"This thesis is dedicated to my family, whose spirits I am part of and whose spirits are part of me":

- My dear late mom, Mrs. Ramrajee Duwarka and my dad, Mr. Ramprith Duwarka, for working tirelessly in ensuring a comfortable life and that education was accessible to me.

- My wife Mashree, who has been extremely supportive, inspirational and patient during the trying times of completing my research work.

- My daughters, Miashka and Vimara, who are my blessings from God and have been the added motivation in me ultimately, completing this work.

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Abstract

The world's population is increasing rapidly and is projected to reach 8 billion within the next few decades. Urban migration is also on the rise and it is estimated that there would be significant growth in Africa and more Africans will reside in urban rather than rural areas by 2030. eThekwini, as a leading city in Africa has to establish practices to enable that it utilizes its current resources optimally and sustainably to cater for its future energy and resource requirements. The role of Smart Grid (SG) systems as an electricity industry enabler has been recognized throughout the developed world. The effective introduction and implementation of SGs is also regarded as a major enabler to realize some of the key objectives at local, provincial and national government levels.

Significant investment has gone into modernizing the existing electricity grid infrastructure at eThekwini to make it smarter, albeit with varying degrees of success. The term "SG" refers to optimizing, automating and modernizing of the electrical network so that it monitors, protects and automatically optimizes the operation of its interconnected elements. In the eThekwini context, this would include the electricity purchase points from Eskom; distributed generation injection points; the high-, medium- and low voltage networks as well as the industrial, commercial and domestic consumers and their applications and devices. The SG is characterized by a two way flow of electricity and information to create an optimized and automated network that has self-healing properties. It would incorporate the benefits of distributed computing and modern communication systems to deliver information in real-time which enables the almost instantaneous balance of supply and demand. SGs will be designed to ensure high levels of reliability, security, quality, availability and will also aim to improve economic productivity, minimize environmental impact, maximize safety and improve quality of life.

The aim, objective and research question of this study will address as to how eThekwini's SG maturity levels compare to local and international peers, whether the SG technology deployment is aligned with its objectives, to ascertain the impact of SG implementation and whether the anticipated benefits are being realized. The concept of SG has only been recently formalized at eThekwini and very little research has been conducted in this area which this study aims to address.

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List of Abbreviations

3G	Third Generation
4G	Fourth Generation
A	Ampere
AC	Alternating Current
ACS	Advanced Control System
ADMS	Advanced Distribution Management System
AM	Asset Management
AMI	Advanced Metering Infrastructure
APN	Authenticated Private Network
AR	Auto Recloser
BPL	Broadband Power Line
C&I	Commercial and Industrial
CBM	Condition Based Maintenance
CCTV	Closed Circuit Television
CIO	Chief Information Officer
CoCo	Column Controller
COP	Conference of the Parties
CPO	Constant Lumen Output
CPV	Concentrated Photo Voltaic
DA	Distribution Automation
DC	Direct Current
DEA	Department of Environmental Affairs
DG	Distributed Generation
DoE	Department of Energy
DNP	Digital Network Protocol
DSL	Digital Subscriber Line
DSS	Distributor Substation
DWDM	Dense Wavelength Digital Multiplexing
EDI	Electricity Distribution Industry
EEDSM	Energy Efficiency and Demand Side Management
EFI	Earth Fault Indicator
EMEA	Europe, Middle East and Africa
EMS	Energy Management System
ERP	Enterprise Resource Planning
ESI	Electricity Supply Industry
eTE	eThekwini Electricity
FO	Fiber Optic
Gbps	Gigabytes per Second
GE	General Electric
GHG	Green House Gases
GHz	Giga Hertz
GO	Grid Operations
GIS	Geographical Information System
GPRS	General Packet Radio System

GSM	Global System for Mobile
GWh	Giga Watt Hour
HAN	Home Area Network
HPMV	High Pressure Mercury Vapour
HPS	High Pressure Sodium
HV	High Voltage
HVSLI	High Voltage Supply Loss Index
ICT	Information and Communication Technology
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronic Engineers
IMC	Inter Ministerial Committee
IP	Internet Protocol
IT	Information Technology
JCI	Johnson Control Industry
Kbps	Kilobytes per Second
Km	Kilometre
KPA	Key Performance Area
KPI	Key Performance Indicator
KV	Kilo Volt
KWh	Kilo Watt Hour
LAN	Local Area Network
LED	Light Emitting Diode
LFS	Landfill Site
LTE	Long Term Evolution
LuCo	Luminaire Controller
LV	Low Voltage
Mbps	Megabytes per Second
MD	Maximum Demand
MDMS	Meter Data Management System
MH	Metal Halide
MSS	Miniature Substation
MV	Medium Voltage
MVA	Mega Volt Ampere
MVMS	Multi Vendor Master Station
MW	Mega Watt
NAN	Neighbourhood Area Network
NETL	National Energy Technology Library
NERSA	National Energy Regulator of South Africa
NOI	Number of Interruptions
NOLR	Number of Load Reductions
NRS	National Regulatory Standards
NTL	Non Technical Loss
OHM	Overhead Mains
OLC	Outdoor Luminaire Controller
OMM	Optimum Maintenance Mix
OMS	Outage Management System

OPC	Open Process Control
OPGW	Optical Ground Wire
OS	Organization and Structure
OSSTMM	Open Source Security Testing Methodology Manual
PAS	Publicly Accepted Standard
PLC	Power Line Carrier
PMU	Phasor Measurement Unit
PV	Photo Voltaic
QoS	Quality of Supply
RCM	Reliability Centered Maintenance
RFP	Request for Proposal
RMU	Ring Main Unit
RTF	Run to Failure
RTU	Remote Terminal Unit
SA	South Africa
SANEDI	South African National Energy Development Institute
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SAIRI	System Average Interruption Restoration Index
SASGI	South African Smart Grid Initiative
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SeCo	Segment Controller
SE	Societal and Environment
SEF	System Energy Factor
SG	Smart Grid
SGMM	Smart Grid Maturity Model
SM	Smart Metering
SMn	System Minutes
SMD	System Maximum Demand
SMR	Strategy, Management and Regulatory
SMOC	Smart Meter Operational Centre
SMT	Synchrophasor Measurement Technology
SMU	Synchrophasor Measurement Unit
TDM	Time Division Multiplier
TL	Technical Loss
TFI	Through Fault Indicator
TOU	Time of Use
TWh	Tera Watt Hour
UBM	Usage Based Maintenance
UGM	Underground Mains
USA	United States of America
V	Volt
VPO	Virtual Power Output
VAWT	Vertical Axis Wind Turbine
VCI	Value Chain Integration

VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAMPAC	Wide Area Monitoring Protection and Control
WAM	Work and Asset Management
WAN	Wide Area Network

Introduction

There are many views, opinions and perceptions as to what a smart grid (SG) actually is and what is expected from it. A SG is a modernized electrical grid that uses analogue [1] or digital information and communications technology to gather and act on information, such as information about the behaviours of suppliers and consumers in an automated fashion. It aims to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity [2].

The concept of SG could also be seen as a merger of multiple timelines but for the purpose of this study we shall consider it as two time lines. The full implementation of SG will evolve over time and newer horizons will be envisioned with each new era. The first timeline we could call our "Smarter Grid" which already possesses various aspects and characteristics that is expected from a SG. It offers valuable technologies that have already been deployed or those that could be deployed in the near future. The focus is mostly on improving efficiency, reducing cost, making services more affordable and minimizing environmental impacts. The second timeline we could refer to as the "SG" which represents greater timelines and longer term realization. The objectives of the SG are:

- Ensure reliability
- Reduce costs.
- Promote global competitiveness.
- Reduce carbon footprint
- Accommodate all energy sources.
- Make provision for future advancements and efficiencies

SG Definitions

There are various definitions and descriptions of what a SG actually is and different perceptions and schools of thought on each. All of them are applicable in some way when referenced to the context in which they is used. Listed below are four definitions which are rather interesting and describes what a modern day SG is and entails.

Definition 1

This SG definition is based upon the description found in the Energy Independence and Security Act of 2007. The term "SG" refers to a modernization of the electricity delivery system so it monitors, protects and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high-voltage network and distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers including their thermostats, electric vehicles, appliances and other household device [3]

Definition2
"The SG is a vision of the future electricity delivery infrastructure that improves network efficiency and resilience, while empowering consumers and addressing energy sustainability concerns." [4]

Definition 3
Zibelman (2007) describes SGs as an evolution of conventional grids in areas such as: [6]

- Transitioning the grid from a mostly unidirectional radial distribution system to a multi-directional grid
- Converting from an electro-mechanical system to a primarily digital one
- Moving to an interactive grid that actively involves end-users (or at least improves data and flexibility of end-users

Modern SG Characteristics

The following are general characteristics of a typical SG: [3]

- Encourage consumer participation
- Accommodate all generation sources
- Accommodate all energy storage options
- Optimize asset utilization
- Maximize efficiency
- Self healing capabilities
- Resilient to attack and natural disasters
- Enable new products and services,
- Improved power quality

Conceptual Model of a Smart Grid
The conceptual model illustrated in figure 1 [7] describes the various components of a SG. It comprises of decision making devices, systems and programs that exchange information to perform and carry out certain applications. The illustration indicates the merging of the attributes from the various domain specific areas which include the enablers and applications which could be used to identify enablers and paths of communication within the SG. It also shows the possible intra- and inter-domain interactions along with their respective applications.

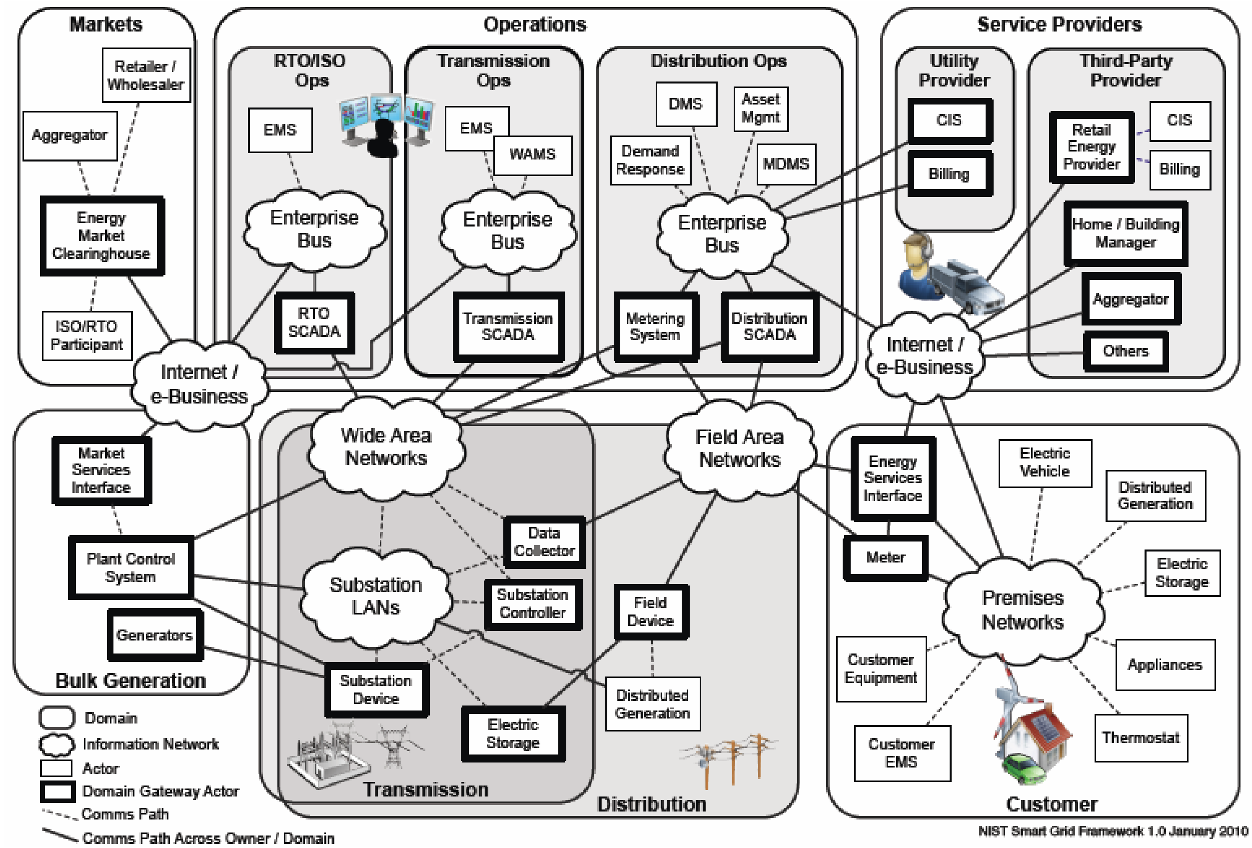

Figure 1: Conceptual Model of a SG [7]

SG Benefits

The 5 category types of SG benefits are as follows: [3]

Reliability and Quality

The SG should improve reliability and quality of electrical power by minimizing the frequency and duration of outages and by utilizing the self healing qualities of the power system.

Cyber Security and Safety

The highest levels of safety and reliability should be achieved by the system continuously monitoring itself to detect for abnormal, unsafe and insecure conditions.

Energy Efficiency

The SG should promote energy efficiency, reduced system maximum demands and minimize overall energy losses. It should also possess the ability to induce end-users to reduce the demand on the electrical system.

Environmental and Conservation
The SG should promote a cleaner and healthier environment. Greenhouse gases (GHG) and other pollutants should be minimized by supporting renewable energy sources and reducing dependence on inefficient generation methods.

Financial benefits
The SG should offer economic benefits across all sectors and to all stakeholders. Operational costs should be driven down and customers should have the flexibility of pricing and tariff choices as well as access to energy information.

SG Challenges

Many procedural and technical challenges are posed when moving towards a smarter grid and then ultimately the ideal SG. These challenges will entail a total paradigm shift and are summarized below. [3]

Procedural Challenges
Prioritizing the challenges that face the SG is of paramount importance as this could form the foundation of what is to come and future developments in this regard. There should be collaboration within the industry to collectively segregate and address challenges. Some of the procedural challenges that need to be met are:

- Broad Set of Stakeholders
- Complexity of the SG
- Transition to SG
- Ensuring Cyber Security of Systems
- Consensus on Standards
- Development and Support of Standards
- Research and Development
- Having a Critical Mass

Technical Challenges
The integration of the various systems across different sectors of the system poses significant technical challenges. Some of the anticipated technical challenges are:

- Integration of Smart Equipment
- Cyber Security
- Information Privacy
- Data Management
- Communication Infrastructure
- Various Software Applications

SG Networking

The SG can be classified as a "system of systems" or a "network of networks". These would include electrical power, communication systems, interconnectivity along with the various applications. This will also entail the interconnection of various networks to provide end-to-end services between stakeholders, the intelligent electronic devices (IEDs) and the various applications. Figure 2 [8] illustrates the layout of a multi service SG infrastructure.

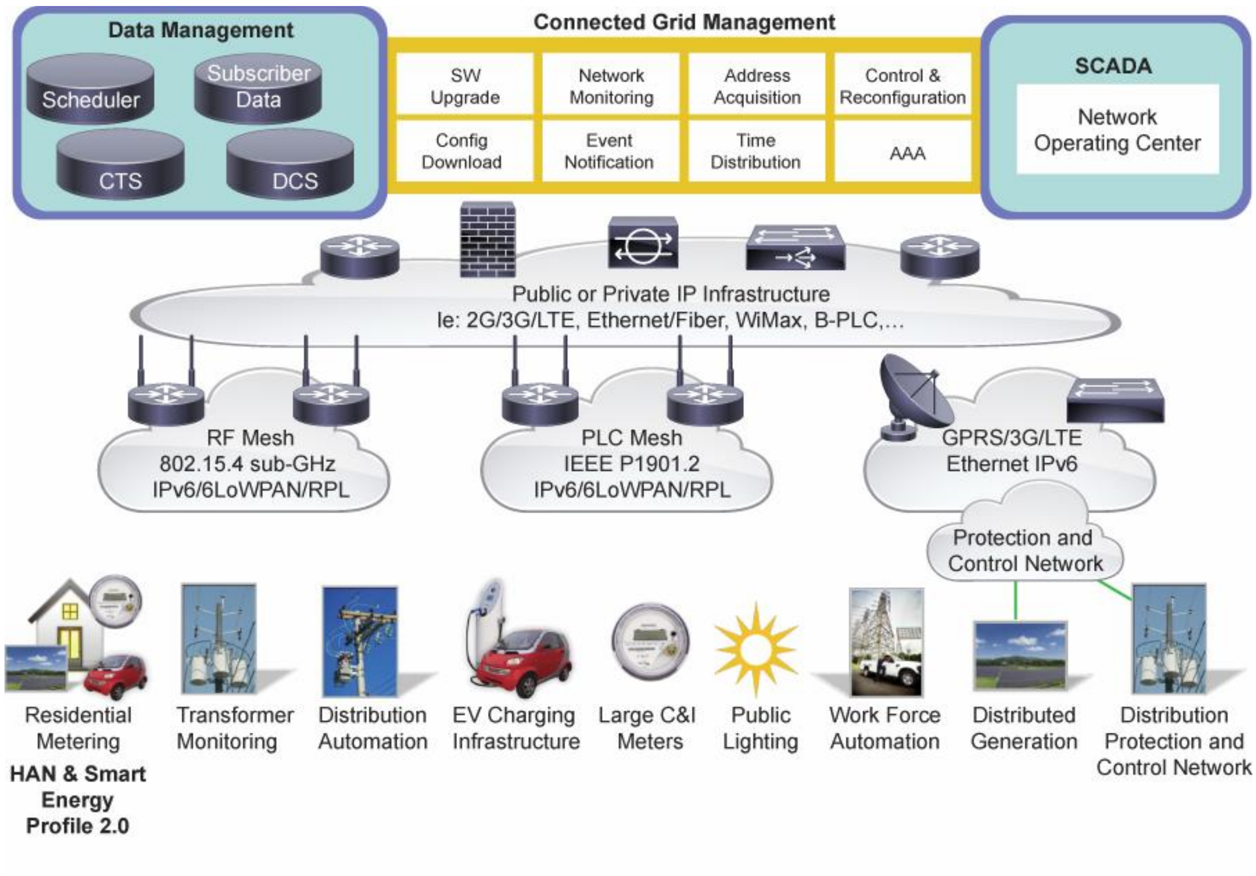

Figure 2: Multi-Services Infrastructure for Last Mile SG Transformation [8]

In the past with the transition of the various protocols were viable during transition periods with smaller and single application networks. These, however, resulted in high capital and operating expenditure and also posed significant technical challenges. Some of the challenges included the lack of end-to-end capabilities, fast recovery consistency, single point of failures, limiting factors in terms of innovation, lack of scalability and vulnerability to security attacks. An end-to-end communication system (IP running on each and every device) will therefore be a wiser approach for multi-services Field Area Networks (FAN) as shown in figure 2 above [8].

Basis of Study

The role and importance of SGs as an electricity industry enabler has been recognized throughout the developed world. Major European countries, USA, India and a host of other countries bear testament to this. The research question of this study will address as to how SA's leading municipal electricity distributor's SG maturity levels compare to these and other countries, whether the SG Technology deployment is aligned with its objectives, to ascertain the level of impact of SG implementation and whether the anticipated benefits are being realized at eTE.

eTE is classified as the largest municipal electricity distributors in SA, in terms of the energy purchased [9]. During the past financial year, the municipality purchased 11 236 GWh of electrical energy for its area of supply and experienced a system maximum demand of 1755 MW across a customer base of 710 000 [10]. The current focus on SG systems has presented the SA and more specifically, eTE, with an opportunity to assess its SG maturity levels with comparisons to other developed countries. SG systems aim to integrate and enhance upgrades and various technologies with renewable generation, computational ability, sensors, communication ability and increased consumer participation. SGs will be designed to ensure high levels of reliability, security, quality and availability of electrical power. and the designs will also aim to improve economic productivity, minimize environmental impact, maximizing safety and effectively improve the quality of life for those impacted.

The effective introduction and implementation of SGs is regarded as one of the main enablers to realize some of the key objectives at Local, Provincial and National Government levels. The aim of this study is to assess the various areas of SG technologies at eTE and to carry out technology deployment analysis and impact assessment in this regard. The objective of this study is to ascertain whether SG Technology deployment is aligned with its objectives and to also give us an idea of SG maturity levels at eTE

Technology deployment analysis will address the following questions:

- What was purchased, built and deployed?
- Where was it installed?
- How much of the system was affected?
- What does it do?
- What opportunities were created out of this?

Technology deployment analysis will also be grouped in terms of asset categories and the system application. The following areas will be analyzed:

- Communication Systems to support SG
- Distribution Automation
- Distributed Generation
- Smart Lighting

- Smart Metering
- Asset Management

The impact assessment will use empirical data developed by the SG projects with information on how SG technologies are being applied and to also to determine the value of the technology to better inform future decisions. The focus areas will be:

- Peak Demand and Energy Consumption
- Operational Improvements
- Maintenance Improvements
- System Losses
- System Reliability
- Energy Efficiency Improvements
- Financial Impact

Chapter 1

LITERARTURE REVIEW – eTHEKWINI ELECTRICITY

1.1 Research Question

The research questions that this study aims to answer can be summarized as follows:

- How does eTE's maturity levels compare to the other countries?
- How does eTE's SG maturity levels compare to the peer community?
- Is eTE's SG technology deployment aligned with its objectives?
- What is the level of impact of SG implementation?
- Are the anticipated benefits of SG being realized?

1.2 Outline of Study

The study will be structured in a manner that will initially define SG from various perspectives and touch on SG theory which will include SG characteristics, benefits, challenges, networking and discussion of a conceptual model.

The first chapter will focus on the profile of eTE and some of the major challenges that the organization faces. The intention is to put into perspective as to where eTE lies within the context of the South African electricity network and its impact thereof. The challenges discussed will highlight the importance of the implementation of SG systems. This chapter will also look at the formalized SG workgroup at eTE and the various objectives that it aims to achieve. eThekwini Municipality's Smart Cities campaign will also be briefly discussed.

It was decided to include communication systems as the first technical chapter as these systems supports all SG applications. The chapter will look at the history of communication systems at eTE and the evolution of the various communication systems. There will also be a discussion on implemented and pilot projects as well the organization aspirations with regards to communication systems.

Distribution Automation (DA) currently forms the major component of SG implementation at eTE and various projects at HV and MV/LV level will be discussed in this chapter. The implementation of SG systems in this area is probably the most tangible in terms of measuring the various applications and the discussion of the various projects aims to provide some insight in this regard.

Distributed Generation (DG) has been become a term that has been frequently used within the electricity supply industry worldwide. This has mostly been the case since significant focus was put on energy efficiency and the global demand for energy. This chapter will focus of the various DG projects at eThekwini and discuss the two flagship projects in some detail.

The next chapter will focus on the various smart system applications in different areas of the business and will include smart lighting and smart metering (SM). The history and evolution of street lighting at eTE will be discussed along with implemented project that contribute towards the SG objectives. SM is still at the very early stages of implementation at eTE and the chapter will outline the plan for the rollout of these systems. The chapter will also include discussion on asset management (AM) methodology and will include AM principles, key performance areas (KPA), asset care plans, maintenance strategies, AM goals and the various aspects of physical assets.

The chapter on the performance analysis of smart systems at eTE will look at the various technical performance indicators. This will be discussed and analyzed in much detail with comparison to historical data. The chapter will also include discussion and analysis of eTE's statistical financial, system and technical data. There is also discussion and analysis of reports that are generated from the various AM systems.

The last technical chapter will focus entirely on the Smart Grid Maturity Model (SGMM) assessment that was conducted at eTE by the South African National Energy Development Institute (SANEDI). This will include the SGMM background, process, results and aspirations. This chapter is extremely crucial to this study as it provides an insight as to where eTE's SG maturity levels stands when compared to the peer community and other countries.

The final part of the study will include a brief discussion on the various aspects of SG detailed in this study, the limitation of the study, areas for further research and recommendations emanating from the study.

1.3. Profile of eTE

ETE is classified as the largest municipal electricity distributor in South Africa, in terms of energy purchased. During the past financial year, the municipality purchased 11 236 GWh of electrical energy for its area of supply of approximately 2000km^2 and experienced a system maximum demand of 1755 MW across a customer base of 710 000. Electricity is purchased at 275KV at five principal in-feed points, transformed, transmitted, distributed and reticulated at 132KV, 33KV, 11KV, 6.6KV, 380V and 230V levels. The electrical network is highly interconnected and even has a 275KV Eskom interconnector connecting two of its principal substations, as indicated in figure 1.1 below:

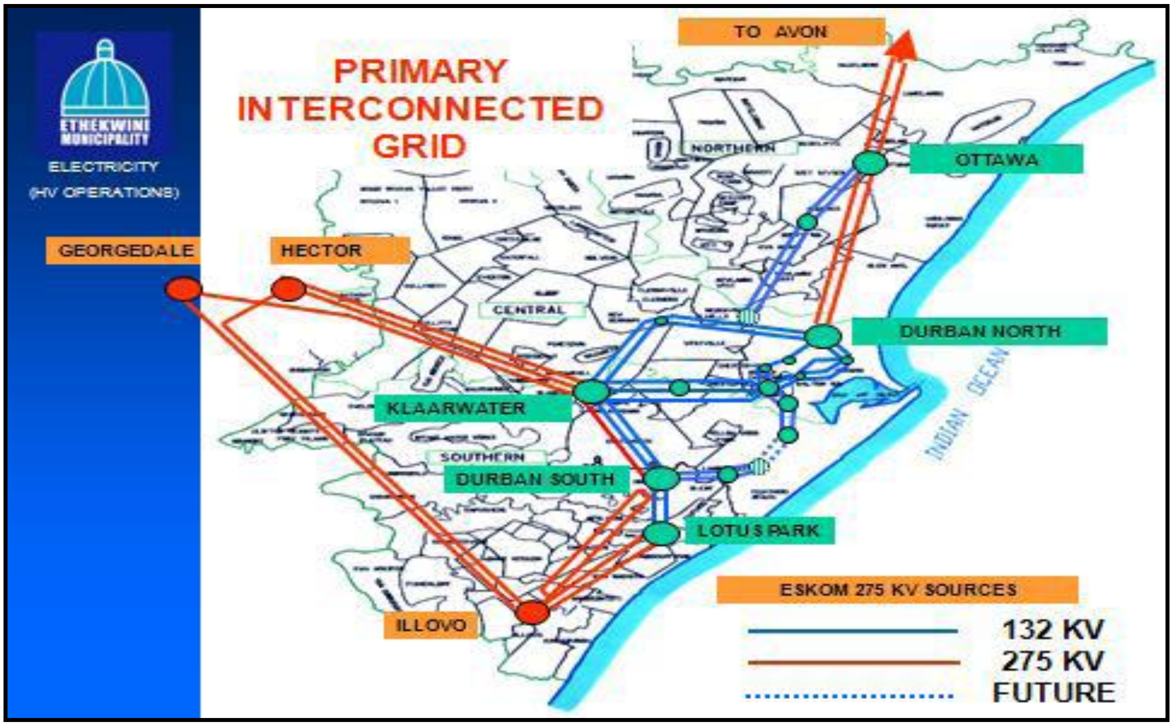

Figure 1.1: Geographical Layout of eTE Electrical Network

The current focus on SG systems has presented South Africa and eTE with an opportunity to assess its SG maturity levels with comparisons to local peers and other developed countries.

1.4. Challenges facing eTE

A summary of the major challenges are:

- Provision of electricity to customers within informal settlements
- Theft of infrastructure
- Theft of energy (non-technical losses)
- Ageing network with increasing maintenance costs
- Poor maintenance practices
- Unplanned outages from overloaded networks
- Rapid growth in demand and geographic expansion
- Weak institutional memory as a result of experienced employees resigning or retiring without the necessary skills transfer.
- Poor documentation of business processes and procedures
- Legacy Information Technology systems with fragmented applications
- Undetected inefficiencies and misallocation of resources
- Increasing compliance requirements with respect to quality of supply and service, finance, health, safety and environment.

1.5. SG Workgroup

In May 2013, eTE formed a dedicated work group whose objective is to consolidate all efforts and work undertaken within the organization and channel it into a common/unified eTE SG vision and strategy [11]. The SG workgroup is accountable to the Electricity Executive and aligns its activities with the Municipality's Smart City vision and to the South African SG Initiative (SASGI), which was established for the strategic direction and implementation of SGs within South Africa. The governance structure is illustrated in figure 1.2.

The scope of the Work Group includes: [11]

- Developing a high level vision of the eTE SG
- Evaluating options pertaining to SG intelligence
- Assessing international experience on SG
- Assessing SG related developments within the SA electricity supply industry
- Establishing a baseline position and assessing the current network capability for SG
- Proposing research, development and deployment opportunities
- Considering pilot projects and evaluating the results from pilot projects
- Determining the high level costs and benefits of developing SGs
- Providing input to standards and specifications
- Developing a SG action plan which will set out detailed actions required to implement the strategy and define roles and responsibilities for the various SG role players

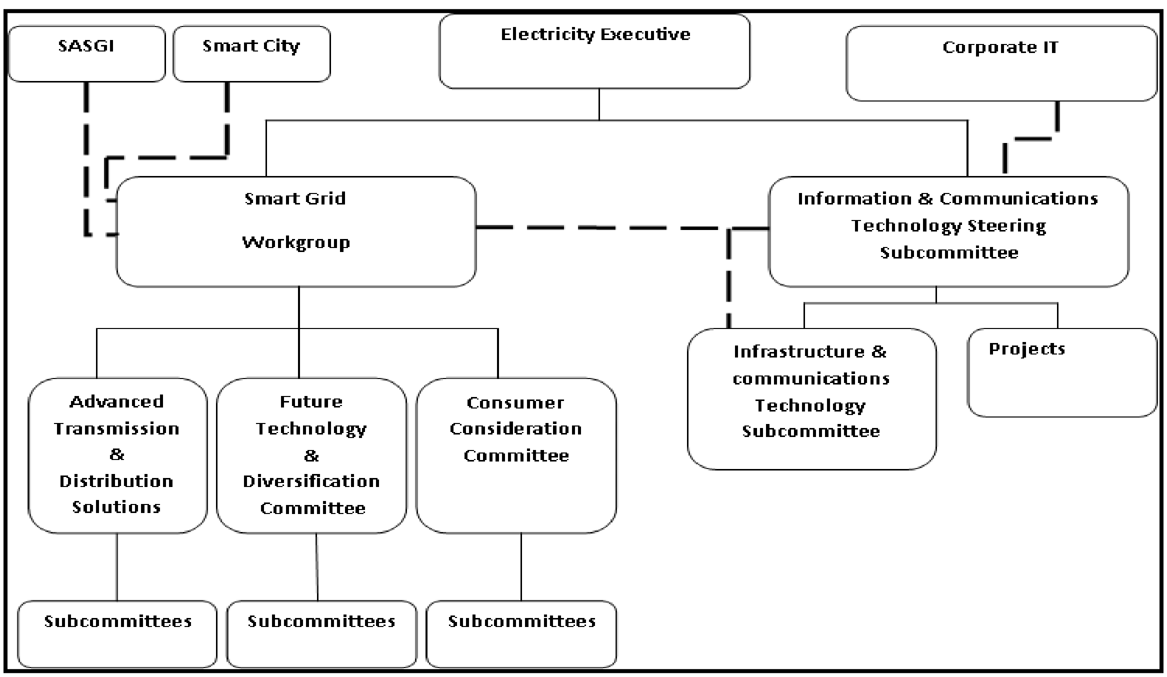

Figure 1.2: eTE SG Governance Structure [11]

Work Group Members are expected to take ownership of the process and the action plan and actively participate in the development of all activities of the WG. In order to derive the benefits from this initiative, full commitment from all members is vital. This includes, but is not limited to:

- Attendance at meetings
- Progress actions between meetings
- Discussions will be held with an open mind and in an atmosphere of mutual respect.

The measures of success for the Working Group will be:

- Acceleration of SG development
- Grid self-healing, security and reliability
- Promote consumer enablement
- Ability to accommodate alternate energy options
- Reduction in environmental impact
- Optimizing asset and resource utilization
- Improving revenue collection

The various committees and sub-committees responsible for the various areas of SG are indicated in figure 1.3.

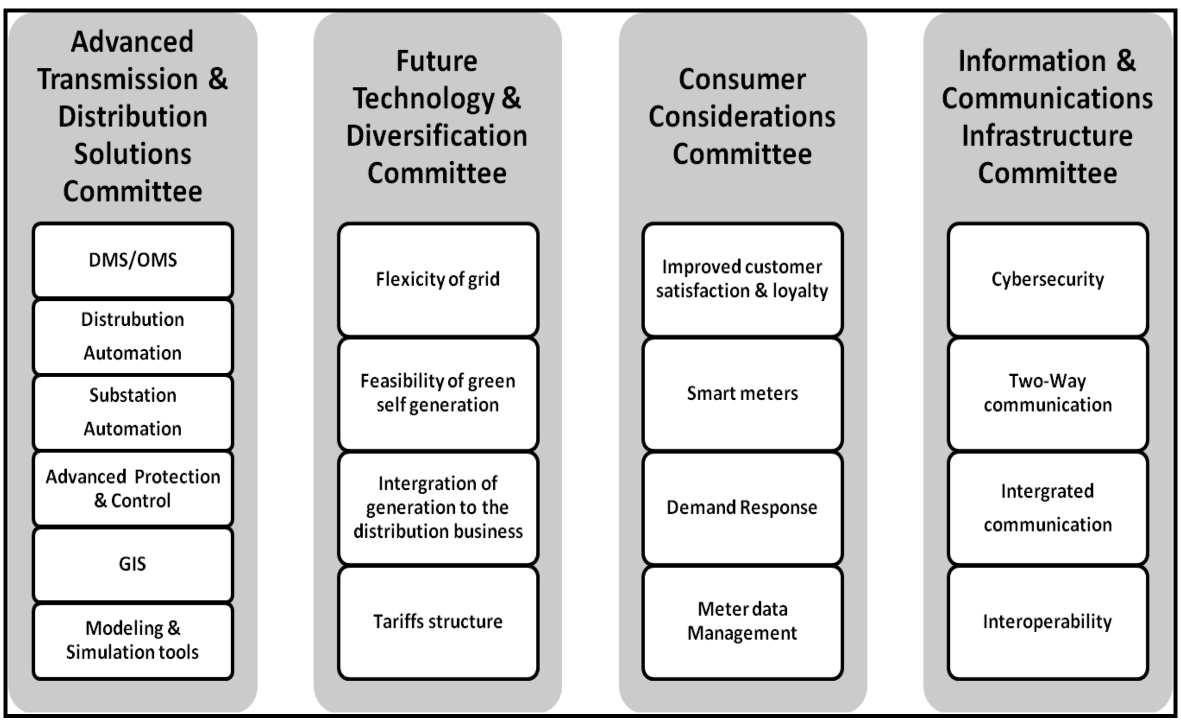

Figure 1.3: eTE SG Committees and Sub-Committees [11]

1.6. SG Strategy Development

The establishment of a consolidated governance structure for the utility with the WG as the driver of the SG journey has led to the need to develop a strategy as its framework and tool. The development of this strategy integrates with the utilities overall strategic plan as well as the cities smart vision. The elements of the strategy will include, amongst others:

- Roadmap and action plan
- Technology plan
- Overall budget
- Resources
- Consolidated approach

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1.7. Smart Cities Campaign

A Smart Cities Summit was held in Durban in July 2012 which focused largely on urban planning in Africa. It was an opportunity for stakeholders to meet and discuss possible solutions and innovative ideas for public sector challenges. The event was held in conjunction with the Department of Environmental Affairs and covered many aspects of modern city management. The summit highlighted five Smart systems, projects or initiatives that could positively impact Africa [12].

1.7.1 Intelligent Transport Management

This was identified as a key factor for a Smart City to succeed. Intelligent technologies such as roadside sensors, controllable street lighting, radio frequency tags and global positioning systems are to be considered to deal with the increasing traffic volumes and intelligent vehicles.

1.7.2 Smart Governments

The creation of Smart Governments by implementing e-Government strategies and principles to improve interaction with citizens and provide accessibility and information to e-Government services also emerged as a major project.

1.7.3 Green Buildings

The Green Council of SA indicated that the number of green buildings was on the rise and home buyers were beginning to consider energy efficient options such as geyser controllers, heat pumps, central heating, central cooling, solar systems and energy efficient lighting when purchasing homes.

1.7.4 Smart Grids

IBM had indicated that SA is one of the countries that are most ready for SGs. It also indicated that various cities in conjunction with Eskom were rolling out Smart Metering (SM) projects which would encourage consumer participation and reduce costs.

1.7.5 Smart Brains and Ideas

It was also stated in order to achieve all of the above; there will be competition over the expertise and the smartest brains that could bring smart ideas and innovative solutions to the city. The quality of life of the citizens will however, be the primary focus.

1.8 Summary of Chapter

eTE is classified as a forerunner in various aspects of engineering and technology deployment in South Africa. It has therefore taken a stance to formalize its activities around SG activities, although this concept has been in existence in a less formal manner for some time now. The formation of the SG workgroup is seen as the first major step in having a team of selected dedicated individuals focusing on this area. The ultimate objective of this WG would be to consolidate all SG related efforts in a manner that would assist the organization in overcoming its various challenges. The challenges facing eTE are not unique and are actually quite similar to challenges faced by municipalities throughout SA and other international countries. The eThekwini Municipality has also embarked on an aggressive Smart City campaign and eTE’s SG initiatives will aim to align into this.

Chapter 2

COMMUNICATION SYSTEMS TO SUPPORT SG

The communication system if often referred to as the backbone of a SG [13]. “In considering the role of communications networks in the SG, it’s important to emphasize that the first enables the second. The adding of intelligence to the network would result in the automation of the various grid functions; and automation isn’t possible without communications networks that enable a two-way flow of data” [14]. “Electric utilities have a long tradition of owning and controlling their own communications networks for mission-critical applications because of concerns about reliability, safety, security and cost. Even in cases where the capital and operational cost is greater than a nonutility alternative, the guarantee of reliability, safety and security inherent in a proprietary utility-owned network often trumps cost concerns”[14].

2.1 History of eTE Communication Systems

Historically all communication systems within eThekwini’s electrical network operated via a copper wire pilot system consisting of cables with a varying numbers of conductors. The pilot wire system provided communication links for the various protection systems, Supervisory Control and Data Administration (SCADA) systems, substation alarms and voice systems. With time, this system aged and became increasingly susceptible to faults which rendered systems inoperative in various areas and also became increasingly costly to repair. It became increasingly clear that the pilot wire network system would not be able to meet the demands of a modern utility’s communication requirement. A long term overall communication network strategy was therefore adopted in 1994 which included the implementation of fiber optic (FO) and wireless systems [13].

The first multi-mode FO cables were laid in the mid 1980’s for the primary application of cable differential protection. However, the first high capacity, longer distance single-mode fiber links between major substations was only installed from the mid-1990s. These FO cables were installed inside the earth wire of overhead line systems optical ground wire (OPGW), as part of the various transmission system refurbishment projects. For underground applications, FO cables were also laid together with electrical cables between the major substations. eTE had now become a forerunner in the field of FO communication in SA and proudly boasted the most extensive FO network of any municipality in the country by 2002. The network currently consists of over 450 km of communication route, consisting of 12 and 24 core FO cables. Approximately 80% of the major substations have a FO technology with the remaining substations connected to the nearest fiber network node via HDSL over copper wire pilot cable.

A new Communication Network Branch was established in January 2000 to focus on the rapidly increasing communication requirements of the electrical network. The primary objectives of the new branch at that stage were to install FO multiplexing systems between the major substations, to provide communication links for the various protection schemes, to enable SCADA systems, to enable the remote interrogation of protection systems, provide links for substation telephones, to remotely monitor quality of supply (QoS) recorders, to support security systems, to enable data communications and various other services of the electrical network [13]. These objectives have largely been achieved, and all major substations are now classified as “reachable” and connected to the FO multiplexer system. The system has also extended to administration system applications.

The current focus is on setting up communication links to the approximately 800 distributor substations (DSS) of the intermediate 11kV level of the electrical system. Cellular radio technology is being introduced to provide a communication channel back to the control centre. Although not under internal control, this technology was accepted due the readily available infrastructure and extensive coverage, which enables fast roll-out throughout the region. The existing simplex radio system, which has served where pilot cables had been deemed irreparable, will gradually be phased out. The new cellular radio units allow more alarms to be reported directly back to the control centre than was previously possible and can also record and log analogue values. These units also have the ability to connect mini Remote Terminal Units (RTU) and RTUs of the new IEC61850 DSSs to the control centre, for automation purposes.

2.2 Reasons for a Private Communication Network:

There are five major reasons as to why private networks are to be considered for communication applications. These are listed below.

2.2.1 Control

The utility would be in complete control and able to determine quality of service (QoS) and packet priority to ensure adequate bandwidth for crucial business applications. The elimination of public traffic will also minimize the probability of network overload that could render the network unavailable, especially during emergency periods.

2.2.2 Coverage

The utility could design the network to ensure coverage where it is required.

2.2.3 Capacity

The utility is in charge of managing this and capacity could be added as and when required as applications are expanded.

2.2.4 Security

The utility could deploy, enforce and manage standard security policies to provide the right level of protection for company data.

2.2.5 Future Proofing

Private wireless broadband networks are not subject to the constant protocol changes that occur in the cellular networks, ensuring that the equipment purchased could remain in service for longer periods.

2.3 eTE Communication Network Architecture

The eTE communication network strategy has been formulated for a period of 20 years, from pre 1995 up until 2015 [13]. The strategy catered for a private, integrated, multi-tier, hierarchical communication network and follows the electrical network in terms of tiers which follows a similar principle as indicated in figure 2.1 below.

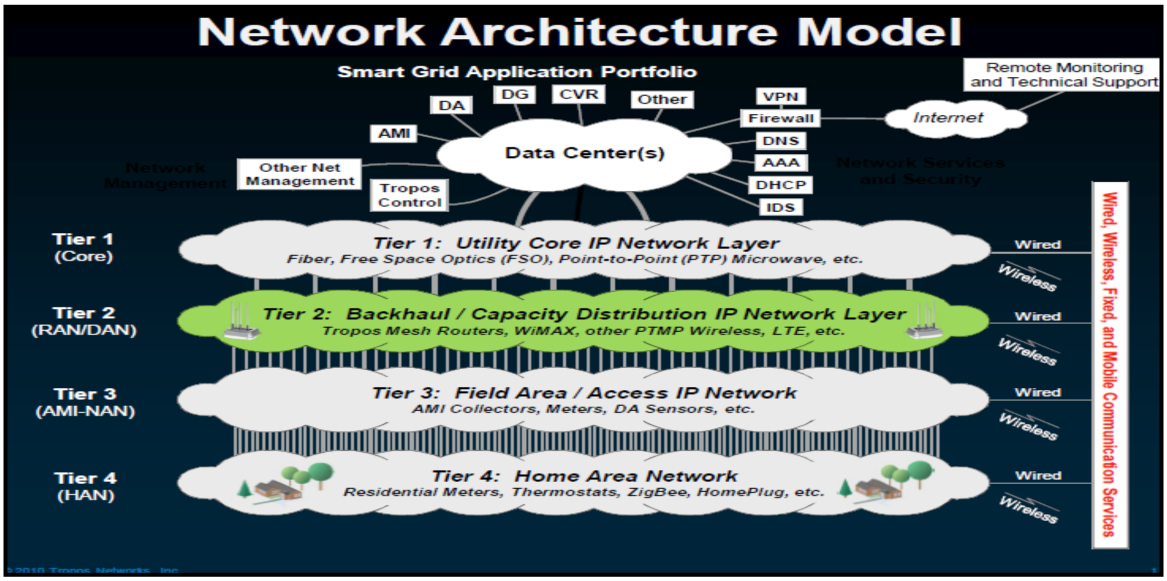

Figure 2.1: Network Architecture Model [15]

The tiers for eTE applications are classified as follows:

2.3.1 Tier 1

This tier is classified as the "Core Network" and consists of the FO systems on the HV network of voltages ranging from 33kV to 275kV.

2.3.2 Tier 2

This tier is classified as the "Backhaul Network" and consists of FO or wireless Wide Area Network (WAN) or Digital Subscriber Line (DSL) on the Medium Voltage (MV) network of voltages ranging from 6.6kV to 11kV.

2.3.3 Tier 3

This tier is classified at the "Field Area Network" and consists of wireless Neighbourhood Area Network (NAN) or Power Line Carrier (PLC) on the Low Voltage (LV) network on voltages ranging from 220V to 400V.

2.3.4 Tier 4

This tier is classified as the "Home Area Network (HAN)" and is made up of wireless HAN or PLC on the domestic LV system on a voltage level from 400V to 220V. Table 2.1 below shows a comparison of the various communication technologies, tiers, bandwidths and latency ranges.

The entire spectrum applies to eTE and depends on the application. The technologies listed are Wire Line, Wireless-1 and Wireless-2 technologies

.

Table 2.1: Utility Communication Technologies, Tiers, Bandwidth and Latency Ranges [16]

Communications Technology	**Utility communications tier Backbone (1) Backhaul (2) Field Applications (3) Premises metering/ Load control (4)**	**Technology bandwidth ranges (per second basis)**	**Latency ranges (milliseconds)**
Wire Line Technologies			
Fiber	1.2	1 Gb to 100 Gb	< 2 ms to 10 ms
DSL/ADSL	1.2	256 Kb to 24 Mb ++	< 20ms to 50 ms
Dial- Up	1, 2, 3, 4	28.8 Kb to 56 Kb	> 20ms
BPL	2, 3, 4	256 Kb to 135 Mb	10ms to 75ms
Ripple/DLC	3, 4	56 Kb to 1 Mb	>20ms
Wireless-1 Technologies	Urban 2, 3; 4 Rural 1, 2, 3, 4		
Satellite	2, 3	1 Mb to 40 Mb	>250ms
Microwave	1, 2, 3	10Mb to 10Gb	<5 ms
Licensed- spectrum radio	1, 2, 3, 4	10Mb to > 1Gb	<15 ms
Wireless-2 Technologies	Urban 3; 4 Rural 2, 3, 4		
2G and 3G cellular	3, 4	200Kb to 1Mb	>15ms
4G cellular	3, 4	10Mb to 1Gb+	5ms to 15ms
Mesh (Wi-Fi)(multi radio)	3 , 4	<5Mb	>25 ms

The eTE systems should therefore possess the following characteristics:

- Cover the entire area of supply which is approximately 2000km^2
- Be reliable, secure and scalable.
- Operate on high bandwidth and low latency performance.
- Be fully manageable through a centralized management system

.

2.4 Tier 1 Core Network

Figure 2.2 below illustrates a basic layout of the tier 1 core network at eTE. The communication medium is either optical fiber (12 & 24 core) or pilot cables. The systems are Synchronous Digital Hierarchy (SDH), Dense Wavelength Digital Multiplexing (DWDM) and Ethernet.

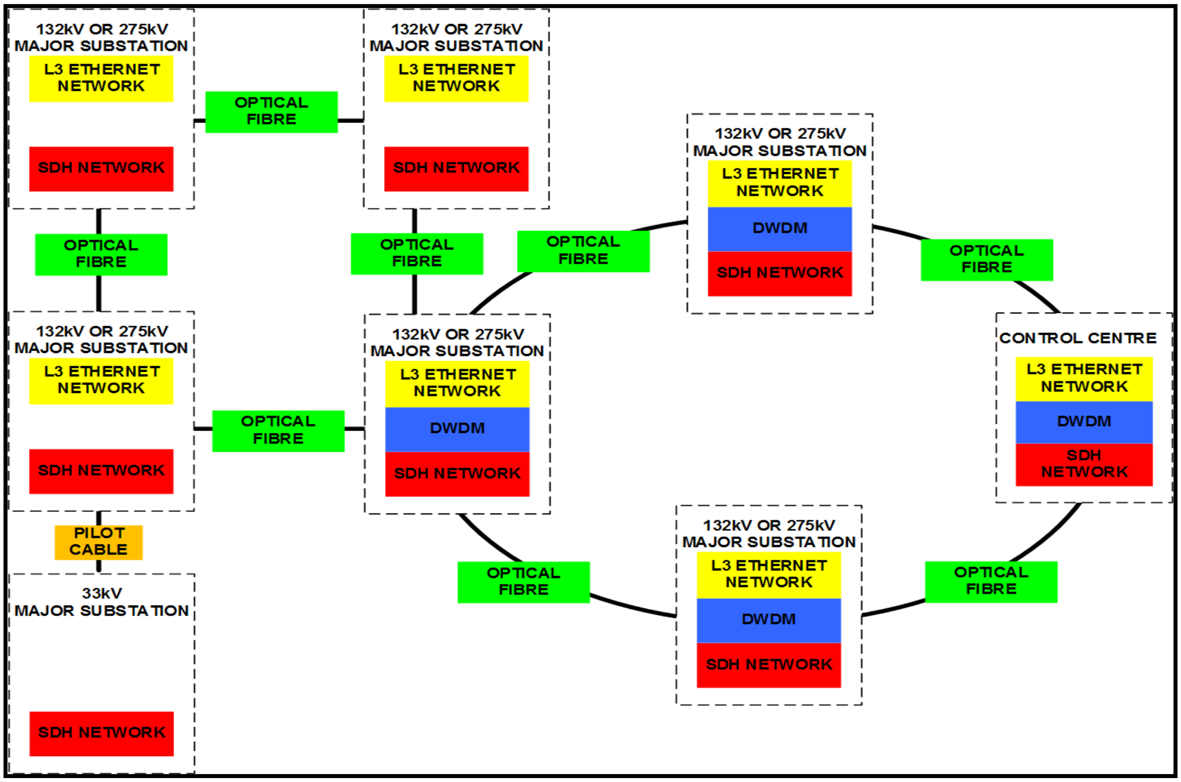

Figure 2.2: Layout of eTE Communication System [17]

The key attributes of the core network are:

- Wide area coverage
- Mesh Architecture (Multipoint to Multipoint)
- Very High Bandwidth (Gbps)
- Low Latency (in the order of 10-100 ms)

The user applications are:

- Substation Automation backbone
- Advanced Metering Infrastructure backbone
- Site Security and Video surveillance
- Voice over Internet Protocol (VOIP) for substations
- IT WAN Backbone

The SDH Network and progress can be summarized as follows: [13]

- Consists of a series of FOX515 Time Division SDH Multiplexers (100 installed)
- Second generation TDM system installed at eTE
- STM-1 155Mbit/s or STM-4 622Mbit/s transmission links
- Third generation system is upgradeable to STM-16 2.5Gbit/s
- Wide array of services can be offered: Teleprotection, Ethernet over SDH (EOS), Data, Voice and Trunk interfaces, SCADA FSK, SCADA IP.

The advantage of a TDM system is that every service has a dedicated time slot first generation system was a PDH system and upgrades to SDH was completed in 2012. The third generation is projected to offer even greater support for IP traffic.

The layer 3 networks are made up of the critical network which is HV SCADA traffic and HV 61850 Engineering Access. The non critical network consists of the HV Closed Circuit Television (CCTV), HV Access Control and HV VOIP. The general layout of these networks is illustrated in figure 2.3 below.

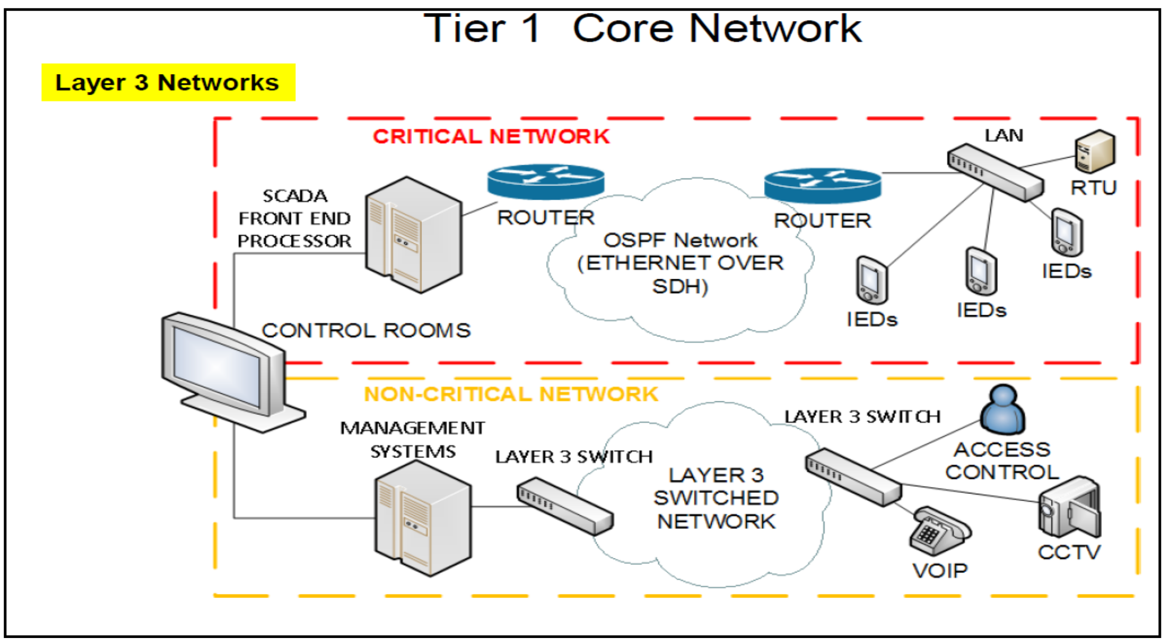

Figure 2.3: Tier 1 Layer 3 Core Network [17]

The following are current communication services supported at HV substations:

- SCADA
- Protection Schemes and Remote Engineering access to relays
- CCTV
- Access control & Security systems

- Remote access of QOS/ Vectographs
- VOIP
- Corporate (Electricity) ITC Links and Municipal Links – Metro Connect

The following are future backhaul services to be supported:

- SCADA
- Remote Engineering access to relays DA
- CCTV DSS
- VOIP DSS
- SM

2.5 Tier 2: Backhaul Network

There are currently over 150 11kV 61850 compliant distributor substations (DSS). These were installed over 2 contracts and a third 11kV switchgear contract is imminent. A basic layout of the tier 2 backhaul network is illustrated in figure 2.4 below.

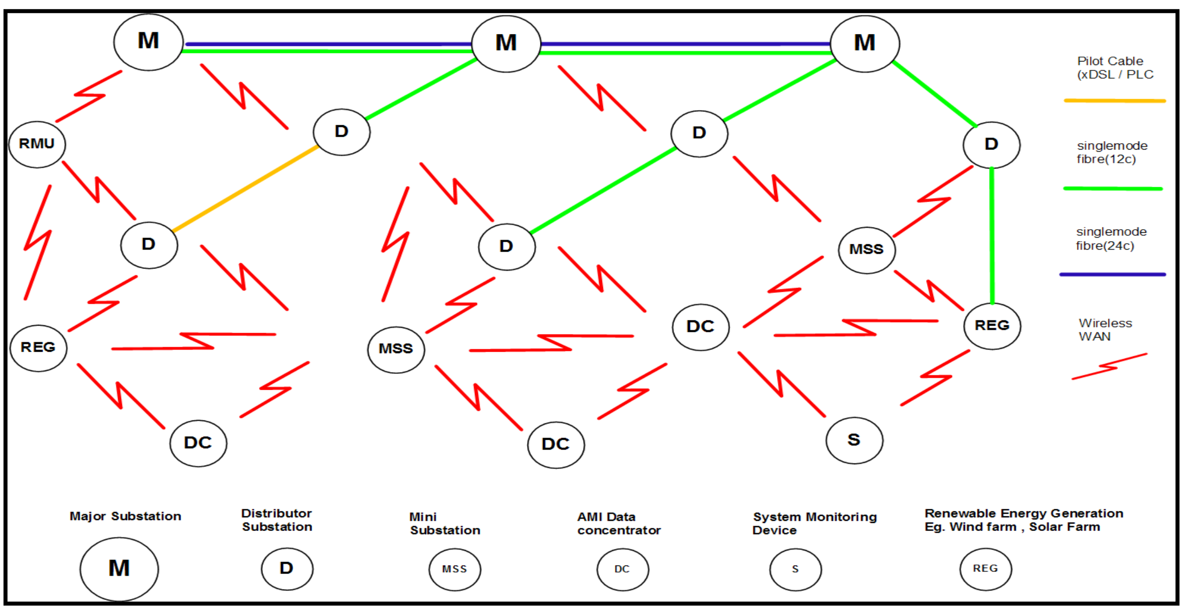

Figure 2.4: Tier 2 Backhaul Network Layout [17]

The key attributes of Wireless WAN & Fibre are:

- Wide area coverage
- Mesh Architecture (Multipoint to Multipoint)
- High bandwidth (Mbps)
- Low latency (in the order of 10-100 ms)

The user applications are:

- SCADA-over-IP (DSS, MSS, RMU, etc)
- Recloser controls
- Phasor Measurements for Quality of Supply
- Renewable Energy Generation (Control and Monitoring)
- Site Security and Video Surveillance
- Voice over IP for substations
- AMI Data Concentrators
- Differential Protection over Fibre only

2.6 Tier 3: Field Area Network (FAN)

This tier is classified at the FAN and consists of wireless NAN or PLC (PLC) on the LV network.

The key attributes of Wireless NAN are:

- Low cost
- Highly integrated
- Ubiquitous coverage
- Moderate bandwidth (250 Kbps)
- Moderate latency (in the order of seconds)

The user applications are:

- SM (Residential & C&I)
- In building devices :
- Load control switches
- In-home displays, etc

2.7 Tier 4: Home Area Network (HAN)

The industry standard for HAN communications has not been defined as yet; however the Zigbee Wireless standard, the GHN standard by IEEE and the LV PLC standards by IEC are current frontrunners in this regard.

The key attributes of Wireless NAN are:

- Low cost
- Highly integrated
- Ubiquitous coverage
- Moderate bandwidth (250 kbps)
- Moderate latency (in the order of seconds)

The user applications are:

- SM (Residential & C&I)
- In building devices :
- Load control switches
- In-home displays, etc

2.8 Projects

2.8.1 Cellular Modem Rollout

A decision was taken in 2008 to implement a mass rollout of General Packet Radio Systems (GPRS) modems to provide a communication medium for alarms due to the inability of the aging copper pilot network to do this. Three types of modems were installed which included a telemetry modem to sites with no RTU's present, DNP3 modem support and DNP3 over serial to DSSs with RTUs. Installations were performed at around 800 sites. Also, approximately 120 battery powered telemetry modems named "oil gauge modems" were installed to provide a means of monitoring the critical HV cable oil and gas alarms. A basic layout of this rollout is illustrated in figure 2.5 below.

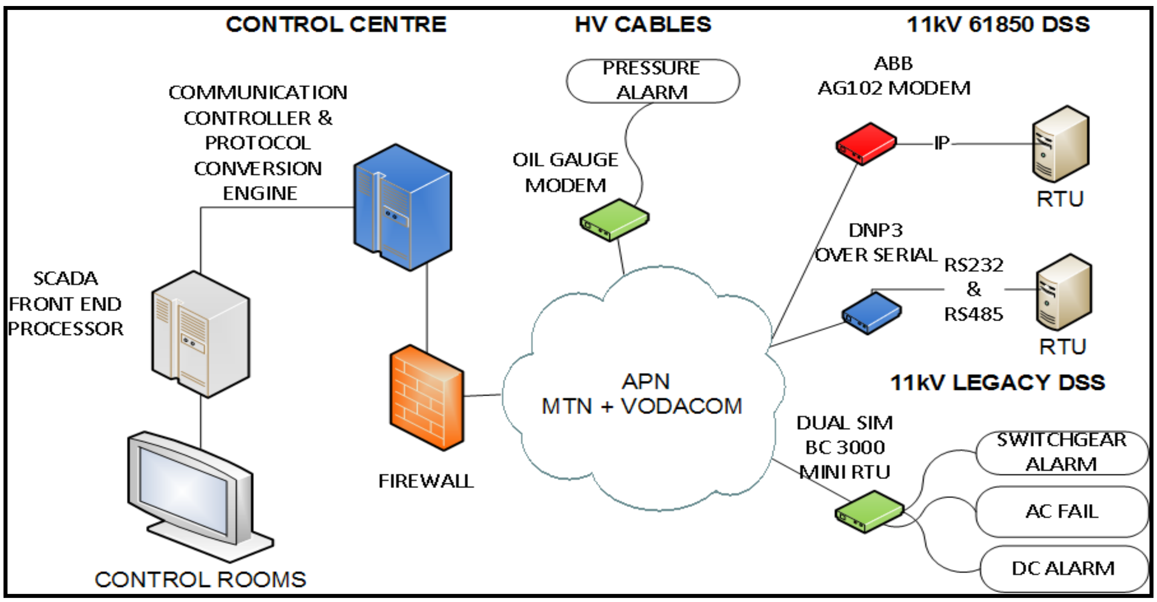

Figure 2.5: Cellular Modem Rollout [17]

2.8.2 Management Systems

This system was installed to enable eTE to centrally manage a large scale network. The system is intended to be scalable and the expansion of IP technology within electric utilities and SG was taken into consideration. The technical systems are very integrated and these are required for debugging, planning, etc. It is unmanned and to be used in the event of faults.

The following are components of the system:

- SDH Network – FOXMAN
- DWDM Network – MEGAVISION
- GPRS – Beyond Wireless Communication Controller's
- Ethernet Network – WHATS UP GOLD

The WAN Access and Management System comprises the following:

- WAN management module
- Access and Authentication module
- Notification module

The Telemetry Web Browser can be described as follows:

- Customized web based application to integrate the use of the ArcGIS platform to monitor the status of telemetry modems installed.
- Original management system was not designed for the scale at the which the project was implemented
- Promotes a holistic view approach

2.8.3 Tier 2 Communication Technologies

The pilot projects in order of preference on the tier 2 communications infrastructure are as follows:

- Kabel-X rapid fibre deployment technology (Copper to Fibre deployment)
- Use of Micro-ducting for fibre installations
- Utility grade xDSL technology over copper pilot cable
- Wireless Mesh systems (WiMax, LTE-4G)
- Investigation of the use of Long Term Evolution (LTE/4G) cellular wireless infrastructure in with Cellular Providers
- Broadband Powerline Communication (BPL) over Copper Pilot networks

The DSS Communication Link scenarios in order of preference are:

- Fibre link to new DSS
- Fibre link to existing DSS where tubing present

- Fibre link to existing DSS via Kabel-X copper to fibre deployment method
- xDSL link via Pilot cable to existing DSS
- Wireless Mesh link to existing DSS with no tubing and has degraded pilot cables
- GPRS links to existing DSS

The installation of xDSL communication equipment is as follows:

- xDSL is a fixed medium; it has the potential to provide secure, reliable & sufficient bandwidth for backhaul links.
- xDSL only to be installed to DSS where the pilot cable is still healthy.

The installation of Wireless Mesh system (4G) is as follows:

- Wireless Mesh system to comprise of backhaul (tier 2) and field area links (tier 3)
- Wireless Mesh links can provide communication links for the DA DSS's, Ring Main Units (RMU), Miniature Substations (MSS), Auto Reclosers (AR); etc.
- Backhaul links for Advanced Metering Infrastructure (AMI) concentrators.

2.8.4 Fibre to DSS

The various phases of fiber installations to new DSSs are as follows:

- Phase 1: Installation of fibre cable to new DSS's directly connected to new Major Substations
- Phase 2 - Installation of fibre cable to new 'cut-in' DSS's from adjacent DSS's
- Phase 3- Upgrade Code of Practice to use Micro ducts

The fiber Installations to existing DSSs is done in the following ways:

- Installation of fibre through existing fibre ducts
- Installation of fibre via Kabel-X method to DSS where pilot cable is repairable and cable differential schemes have been decommissioned.
- Planning of new links to existing DSSs

The technological benefits are as follows:

- FOs is a more reliable medium for differential protection
- FOs provide higher capacity for additional services such as SCADA
- Medium will be fully monitored as opposed to pilot cables
- Lower risk of theft

2.9 Summary of Chapter

eTE has placed a lot of emphasis on equipping its network with the latest available technologies in communication systems, as well as catering for all variables that could arise out of an integrated and complex SG system. The communication system is referred to as the “backbone” of the SG system as it supports all applications and effective operations of the various components of the SG system. eTE has been extremely visionary in its approach and the first major step was the formation of the Communications Network Branch which became responsible for all activities in this area. The organization has always been at the forefront of communication technology deployment as is evident with the various pilot and implemented projects that have been rolled out. There is a lot of debate around the “public versus private network” issue and eTE has decided to opt for private networks, where possible, for the purpose of security and being able to be in control of the network, amongst other reasons. The network architecture model is based on first world standard and classifies the various tiers of the communication system.

Chapter 3

ETE DISTRIBUTION AUTOMATION (DA)

3.1 DA at MV and LV Levels at eTE

DA is a term that describes the integration of various technologies and protocols that enables the electrical distribution system to be remotely controlled, monitored and operated. eTE has embarked on various DA projects as part of the SG Initiative to all distributor substations (DSS), ring main units (RMU), auto-reclosers (AR), through fault indicators (TFI), kiosk and miniature substations (MSS). This is being done in conjunction with various other projects to improve reliability, increase efficiency, optimize asset utilization and maximize performance of the electrical distribution system, thereby increasing visibility of the entire grid and providing safe, reliable and high quality power to consumers. The chapter shall focus on DA initiatives from a MV and LV perspective.

The benefits of DA can be summarized as follows: [18]

- Improves data acquisition for engineering and strategic planning of the network by making valuable information available to the relevant stakeholders.
- Improves network performance as a result of a reduction in system outages and greater security of supply.
- Improves operator efficiency and safety.
- The intelligent devices allow for early detection of incipient faults and equipment failure and therefore will assist in fault location hence reduce restoration times.
- Improves overall quality of service and electricity supply to consumers.

RTUs have been installed, tested and commissioned in 455 out of a total of 755 DSSs. The main objective of this initiative is to enable remote monitoring and control of DSSs and these RTUs allow for remote data acquisition and control to these substations. Communication to the RTUs was made possible by the installation of internet protocol (IP) modems using GPRS. The advantages of IP communication include the facility for relevant staff to carry out updates, configuration changes and remote diagnostics of faults without the need to physically drive to site, thereby improving the response times to faults. Open VPN was implemented to take care of security vulnerabilities that GPRS introduces.

A total of 71 RMUs have been installed with 9 of these sites having been commissioned and a total of 74 ARs have been installed with SCADA functionality. Two TFI sites have been configured and commissioned for testing purposes to monitor the performance of the devices and to ensure it meets system requirements. The TFI will serve as an indicator to field staff as to where a fault has occurred. If a fault occurs, the TFI will trigger an LED on the sensing unit mounted on the line and an alarm will be sent to control room and the faults team could then be dispatched as soon as possible. The kiosk pilot site has been tested and commissioned and the first batch of kiosks are currently being wired and prepared for the mini RTU installation. This will allow the control room staff to detect when a fuse is blown and obtain earth fault indications as well as monitor various measurable parameters of the substation.

RTUs act as the electronic interface to the switchgear providing constant monitoring of inputs, outputs, data acquisition and secure controls to safely operate the substation. The RTU's are supplied by various companies such as Nitcom, Actom, and ABB which are installed at various DSS sites.

3.1.1 Projects

3.1.1.1 ABB RTU's

The MV/LV network has been operated with limited remote monitoring and control for decades. With the SG drive, eTE has decided to enable remote monitoring and control of all DSSs. To achieve this, eTE have acquired the services of ABB to supply, deliver, install and commission RTUs within the MV electrical network. These are currently being installed in both existing (retrofits) and new DSSs.

The main objective of this project is to enable remote monitoring and control of DSSs. This is achieved by the installation and commissioning of ABB RTU560G RTUs. Due to huge financial implications of this massive roll out, a cost effective communication solution using GPRS was chosen. A study was conducted to ascertain the relevant RTU configuration strategy that will minimize data costs on the GPRS network and it was determined that internet protocol (IP) technology should be implemented.

The scope of work is not deterministic as the number of sites to be done is dependent on a number of variables i.e. ABB delivery times, sites that will be difficult to interface to Nitcom etc.

The commissioning process includes:

- Decommissioning of existing telemetry units.
- Configuration settings for tele-control hardware and software.
- Creation of master-station databases and single line operator diagrams.
- Commissioning of status, telemetry and control points to the master station.

The existing telemetry unit is left on until the RTU is fully commissioned. All wiring work is done prior to commissioning. Authorized resources are allocated to the contractor to ensure safety. He is also responsible for ensuring that work is done to eTE standard and act as a representative for the commissioning report. The authorized person assists with RTU wiring and commissions the points back to the master station.

A total of fifty retrofit substations have been commissioned to date. A new batch of 50 RTU's has been ordered and shall be installed and commissioned. A total of 45 new sites have been commissioned to date. This project is an ongoing process as and when required.

3.1.1.2 ACTOM C264 RTUs

In 2007, eTE had embarked on a DA project to provide SCADA functionality to the 11kV distribution substations. It has also acquired the services of Actom to supply, deliver, install and commission RTUs within the MV electrical network. The RTUs, specifically the Actom C264s would communicate with the IEDs using an Ethernet connection. All data collected from the IEDs would be sent back to SCADA serially over GPRS. TE had acquired the services of Beyond Wireless to provide communications between the DSS and the control centre. The scope of work is as follows:

- Configuration of C264 RTUs.
- Creation of master-station databases and single line operator diagrams.
- Install and Configure GPRS Modem.
- Commissioning of status, telemetry and control points to the master station.

All Actom C264 RTUs shall be re-configured to communicate to the SCADA master station via Ethernet using DNP3 over TCP/IP. The protection IEDs shall also be configured to communicate to the RTU with the respective IP addressing. The migration from serial to IP shall include the use of an IP modem for which provision has been made. The configuration of the modem shall be done prior to the site installation. Once all sites have been migrated over to IP, all sites shall be re-commissioned to the control centre. Figure 3.1 illustrates the layout of the software architecture of the system. All sites are currently on serial and a test upgrade has been done to the Moses Mabhida P2 substation from serial to IP. The upgrade was successful and has been fully commissioned to the control centre. The next site to be migrated is Moses Mabhida P1 and thereafter the remainder of the fiber sites.

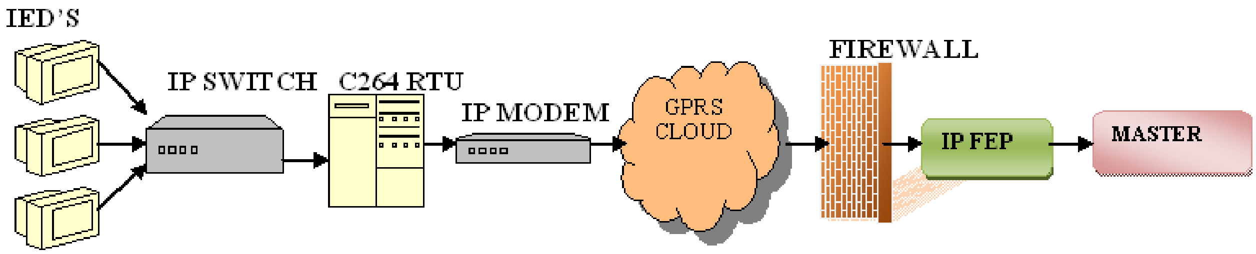

Figure 3.1: C264 RTU Software Architecture [18]

3.1.1.3 NITCOM RTUs

As part of the DA project to provide SCADA visibility to all DSSs, eTE has acquired the services of Nitcom to supply, deliver, install and commission RTUs within the MV electrical network. The project began in late 2010 with the first phase of 25 Nitcom RTUs. As the phases have progressed there has been development and improvements to the Nitcom RTU technology and hence the systems have evolved with each passing phase.

The Nitcom RTUs are installed as retrofits within existing substations to provide visibility to the control room staff. Each RTU will provide the ability to control switchgear (trip and close), view the breaker and relay statuses, and monitor various measurable parameters of the substation. Nitcom is responsible for the supply, delivery, installation and commissioning of the RTUs. eThekwini and Nitcom staff work in conjunction to complete the required tasks. The installation team will ensure that the RTU is installed on site and all of the electrical wiring between the RTU and field equipment is completed. Thereafter the commissioning team will ensure that the SCADA (SCADA) configuration is correct.

As of October 2013 there have been 4 phases of installations completed and commissioned. The fifth phase has commenced in November 2013. A total of 200 projects are earmarked with open process control (OPC) server, virtual RTU and a combination of OPC and virtual RTU technologies. For the Nitcom RTU there are currently 2 software architectures in place. The initial setup comprised an OPC server that all the Nitcom RTUs communicated with and the SCADA master station in turn then polled the OPC server for all the data from the RTUs. The OPC server is also sometimes referred to as the IOServer or Nitcom server. A layout of the Nitcom OPC server is illustrated in figure 3.2.

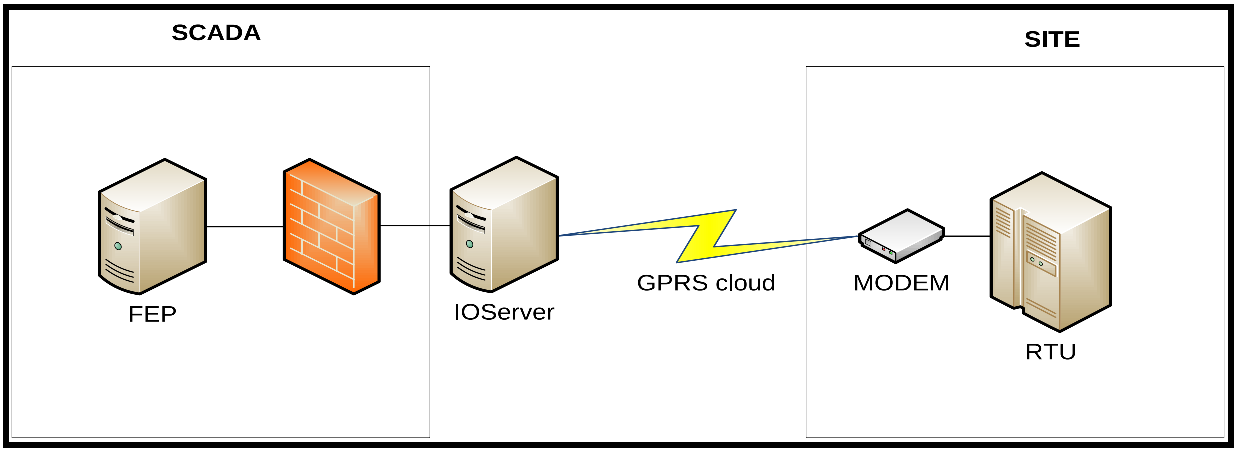

Figure 3.2: Summary of the Nitcom OPC server [18]

During the third phase of the Nitcom RTU installations, eTE had requested a move away from the OPC server which was seen as a single point of failure. The new architecture did away with the OPC server and introduced a new modem which is a Windows CE box with a virtual RTU that spoke to the Master Station individually. In the absence of the OPC server, the security, authentication and encryption functionality were diverted to the individual modems. The modem communicated with the open VPN server via a shared security key and provided access to the SCADA LAN. A simplified layout of the new modem technology is illustrated in figure 3.3.

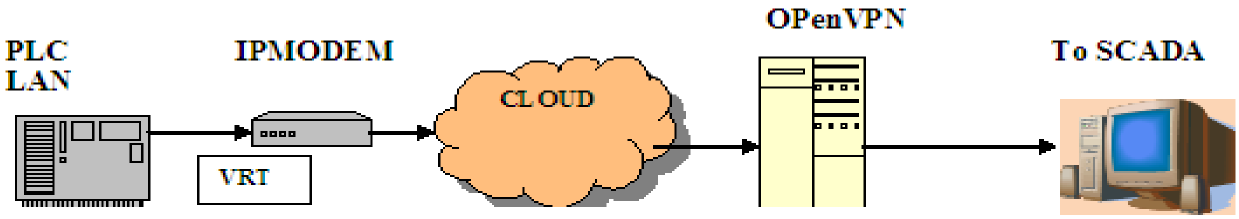

Figure 3.3: Simplified layout of new modem technology [18]

3.1.1.4 Ring Main Unit Automation (Schneider T200)

In 2005, eTE had taken a strategic business decision to purchase all MV equipment with SCADA functionality, and these included ring main units (RMU). However, many MV devices were installed on site but never commissioned onto the SCADA system, largely owing to a lack of technical resources. The project was then re-formalized in 2012 and there was a bit of uncertainty around the amount of RMUs that were installed. Many RMUs have been deployed as temporary solutions and therefore may be decommissioned at some stage, however some temporary devices may remain in commission for periods of up to five years and therefore

SCADA functionality is essential. A total of 112 RMUs were procured, with 41 in commission at known locations, 21 that were out of commission and a further 50 at unknown locations.

The objective of this project is to effectively commission the RMUs to the SCADA master-station for the purpose of remote monitoring and control. The critical path items are:

- An onsite audit of the tele-control system, including the feeder designations
- Configuration settings for modem
- Configuration settings for RMU
- Creation of master-station database and single line operator diagrams
- Commissioning of status, telemetry and control points to the master station

The RMU software architecture is indicated in the figure 3.4. The backend system is currently being prepared for testing and commissioning. To date, a total of 9 RMUs have been commissioned. The configuration of the modem shall be done prior to the site installation. The master station databases and operator single line diagrams shall be completed in-station. The network settings of the RMU shall be carried out on site and the RMU configuration shall be remotely done.

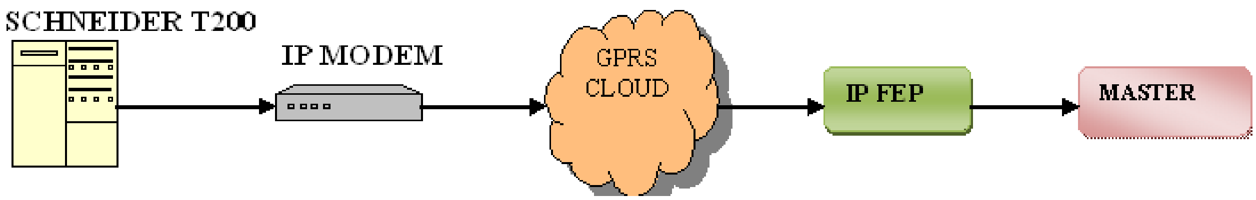

Figure 3.4: RMU Software Architecture [18]

3.1.1.5 AR Automation

In 2005, eTE had taken a strategic business decision to purchase all MV equipment with SCADA functionality and these included auto reclosers (ARs). However, many MV devices were installed on site but never commissioned onto the SCADA system, largely owing to a lack of technical resources. The project was re-formalized in 2012 and there are currently 76 Nulec ARs with embedded RTUs installed on site at known locations, but none have been fully commissioned as yet.

The objective of this project is to effectively commission the ARs to the SCADA master station for the purpose of remote monitoring and control. The critical path items are as follows:

- An onsite audit of the tele-control system, including the line designations
- Configuration settings for modem
- Configuration settings for AR

- Creation of master-station databases and single line operator diagrams
- Commissioning of status, telemetry and control points to the master station

The AR software architecture is indicated in the figure 3.5. The control unit of the AR is currently being tested and monitored. The configuration of the modem shall be done prior to the site installation. The master station databases and operator single line diagrams shall be completed in-station. The AR settings and configuration shall be done onsite.

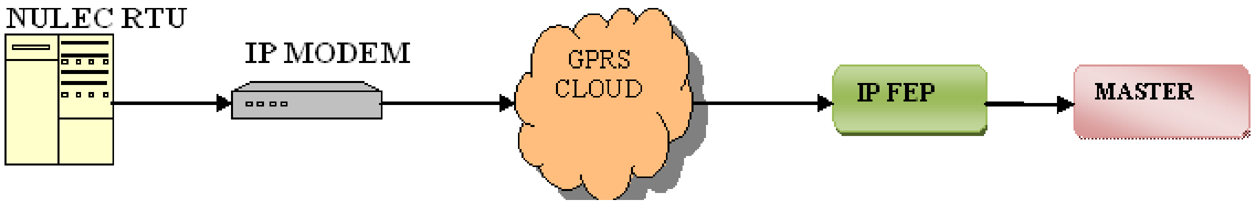

Figure 3.5: AR Software Architecture [18]

3.1.1.6 Kiosk Automation

It is the intention to have every kiosk retrofitted with a mini RTU that will provide SCADA functionality for remote monitoring. The RTU shall monitor the loads as well as the earth fault indicators (EFI) and detect for blown fuses. Of the 2800 kiosks on site, the first batch of 1000 kiosks shall be commissioned during the financial years 2014/2015, 2015/2016 and 2016/2017. The proposed kiosk software architecture is indicated in figure 3.6. The pilot site at Northway kiosk has been chosen to test the solution with the split type current transformers (CT) and to establish the wiring design.

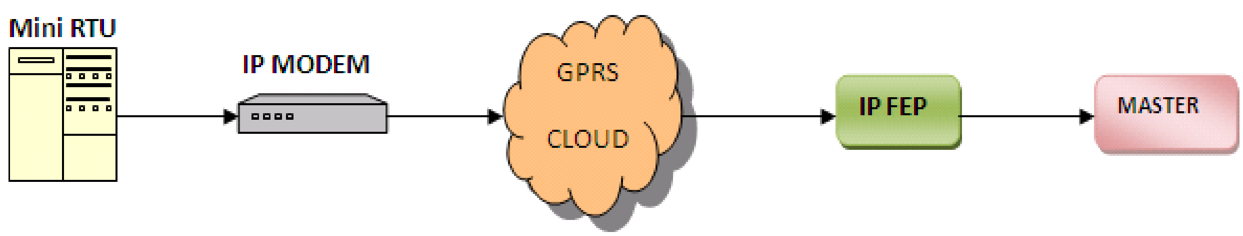

Figure 3.6: Proposed Kiosk Software Architecture [18]

The EFI, blown fuse indication and loads per phase shall be brought back to control via the DNP3 communication protocol over TCP/IP. The 4 Faith IP modems shall be installed at each site for GPRS communications and shall communicate to the open VPN server to allow for access to the SCADA LAN. The mini RTU and indication layout is illustrated in figure 3.7. The pilot site has been tested and commissioned in February 2014. The first batch of kiosks is currently being wired and prepared for the RTU installation and commissioning.

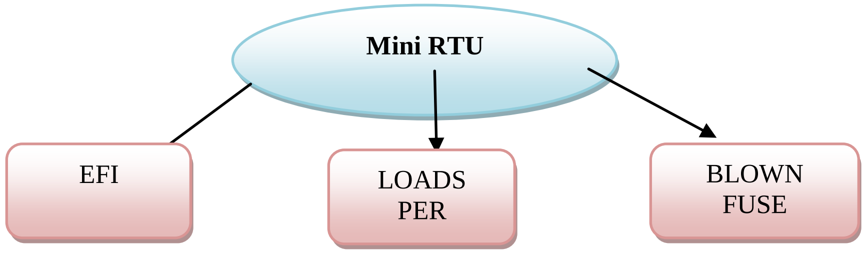

Figure 3.7: Mini RTU and Indication Layout [18]

3.1.1.7 OHM TFI with Controller

A pilot project was conducted with the Horstmann Smart Receiver and it was found that there could be potential benefits from monitoring the overhead mains system (OHM), especially in terms of monitoring theft and simplifying fault finding. The Horstmann Smart Navigator unit which has a LED indication, as well as a wireless module that communicates via a 2.4 GHz radio frequency to the control box, is clipped onto the OHM as indicated in figure 3.8. The control box consists of a Horstmann Smart Receiver which collates the information from the OHM units. The control box also contains a GPRS/IP modem and a power supply. The Horstmann Smart Receiver supports DNP3 over IP and the network architecture follows that of DSSs where open VPN authentication is used. A second pilot project is currently underway to test the unit and shall be deployed throughout the supply region once all the necessary tests have been completed and all the SCADA requirements met.

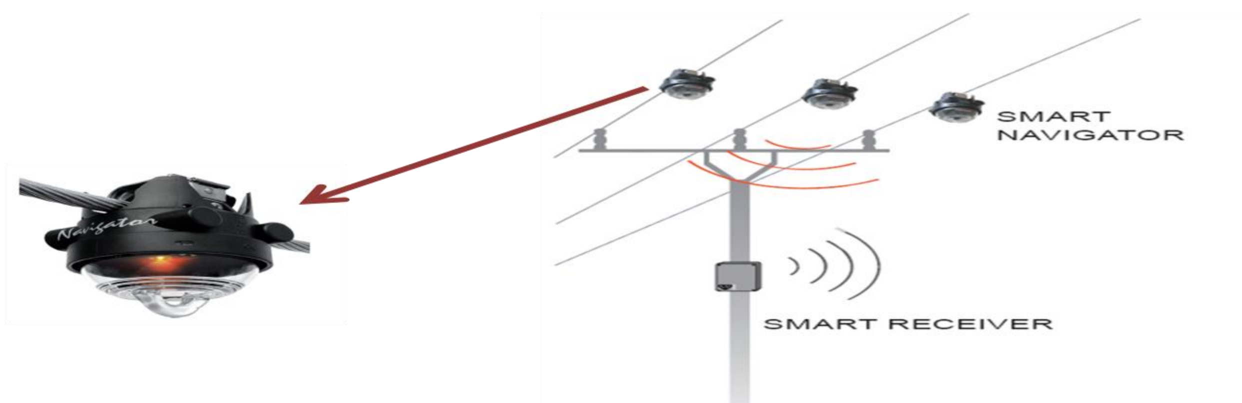

Figure 3.8: TFI on site layout [18]

3.1.1.8 Mini Substation Automation

Phase 3 shall incorporate the automation of the MSS with a cost effective and reliable solution. The proposed solution shall be tested and monitored on the SCADA system to check it meets all requirements. The RTU and power meter options will both be considered for implementation.

In the first option, a RTU could be installed as indicated in figure 4.9, to remotely access the MSS and obtain the analog data, fuse blown alarms, door alarms and EFI alarm. There are much more facilities available on the RTU that are not needed for MSS applications. The cost of an RTU is rather significant and great consideration will be given to space constraints as well as the risk of theft and vandalism. Communication to the RTU will be via GPRS and this will require the use of an IP modem.

In the second option, a power meter could be installed, also as indicated in figure 3.9 below to remotely obtain the analog data, fuse blown alarms and EFI alarms. This system does however have limitations as the power meter can only accommodate 12 of the 24 points that are required. This would then mean that 2 power meters would be required per site. The power meter is relatively small and could be mounted inside the MSS and the cost is approximately 75% lower than that of the RTU.

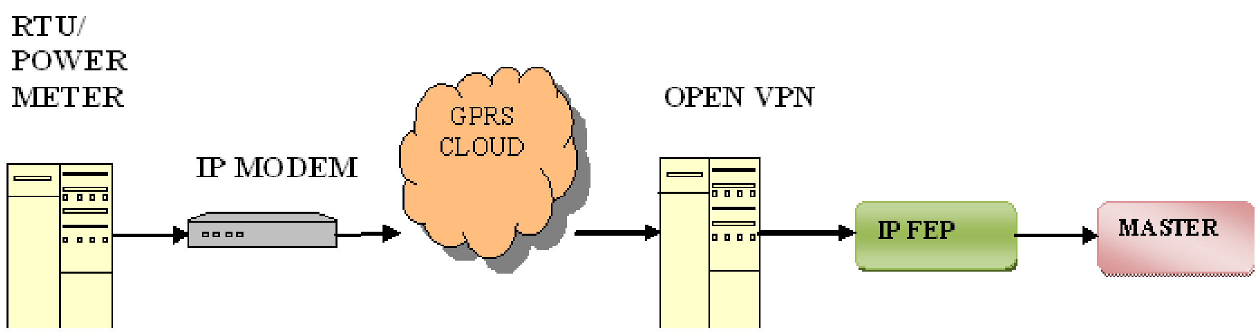

Figure 3.9: Mini Sub Software Architecture [18]

3.1.1.9 Advanced Distribution Management System (ADMS)

eTE historically operated on a manual outage management process. The Control rooms have large mimic wall boards which represent the electrical network. The ERP Ellipse system is used to log faults by creating a "Work Request" and thereafter a "Work Order" is manually created in order to trace the work carried out. There are many actions, in the restoration of the fault, that require manual actions by the relevant controller which are tedious due to the high volume of faults handled. The processes currently used are time consuming and provide little or no real time information to customers.

The current process is functioning adequately due to a committed team who strictly adhere to the business process. However there are major challenges faced, such as:

- The inability of the Contact Centre to respond to the consumer on the progress of a previously reported fault, whether the fault has been assigned, repair is in progress, and an estimate of the restoration time.
- The reporting back of the work progress details from the field staff is delayed.
- Linking of additional work requests sent by Contact Centre for known outages.
- Linking process is inefficient
- The process of creating a work order is very cumbersome as it requires the copying of data already entered in the work request and at times multiple work orders are created should further work be required from the appropriate depot.
- Backlog for completion of work orders

An ADMS solution was therefore sought to address these and various other challenges. In the business case, eTE stated that it is vital to promote technological advancements and improve operational efficiencies. They also intended to integrate the solution with eTE's various operational systems thereby radically improving business processes and assisting to deliver a world class distribution service to the citizens of the eThekwini Municipality. The primary objectives of the project were to:

- Enhance the quality of life for our customers by the network reliability and quality of service we provide.
- Manage diverse processes and systems, and streamline work practices
- Promoting technological development to assist in improving operational efficiencies
- Comply with regulatory requirements – NRS047, NRS048 etc.

eTE therefore required an integrated and automated ADMS to replace the historic manual outage management processes. To meet the requirements of eTE, General Electric (GE) proposed the deployment of a single ADMS solution with the PowerON Advantage feature to cater for the necessary requirements.

At a high level, PowerOn Advantage will have the following key characteristics: [19]

- Integrated and modular ADMS solutions
- Enhanced user experience, supporting ad hoc and process based workflows
- Simplified deployment/upgrade model
- End to end solution based workflows, model synchronization
- HV, MV, and LV modeling & control with advanced application solutions
- Planning applications integration
- Integrated workforce management and mobile solutions
- Managing active distribution networks
- Enabling third party application developments
- Increased use of analytics across operation

The ADMS is designed as a full-featured outage management system (OMS) solution that will provide Dispatchers and Control Room Operators with enhanced workflow capability, intelligent prediction management and a carefully designed user friendly interface. The configurability would be able to support distribution and outage management procedures, thereby improving operational efficiencies and communications in all weather conditions [19].Some of the key features are listed below: [19]

- Network Visualization
- Topology Processing
- Geographic Network Display
- Schematic Generation
- Work Management
- Switching Planning
- Switching and Operating Devices
- Ganged and Un-ganged Operation of Devices
- Clearance Permits and Tagging
- Outage Management
- Call Taking
- Outage Analysis
- Smart Meter Integration
- Restoration Management
- Customer Management
- Outage Reporting
- Crew Management
- Remote Dispatch and Outage Management
- Alarm and Event Management
- Storm Manager
- Additional Features
- Calculation Engine
- Protocol Library
- Load Shed and Restoration Option
- Automation Schemes Option
- SCADA Commissioning
- Distribution Power Analysis
- Fault Level Studies
- Load Transfer Capacity Option
- Time Series Historian Option
- Switching Advisor Option
- Feeder Reconfiguration Option
- Integrated Volt-Var Control

- Fault Location Option
- Dynamic Thermo/Limits Option
- Transmission State Estimation
- Transmission Contingency Analysis

3.2 DA on HV Level at eTE

In terms of the definition in the eTE context, HV shall mean voltages levels of 33KV and above. All projects are being executed in conjunction with various other initiatives to improve reliability, increase efficiency, optimize asset utilization and maximize performance of the electrical network [20].

3.2.1 Projects

3.2.1.1 Software RTU

The objective of the Software RTU is to enable bi-directional real-time data transfer between the Advanced Control System (ACS) SCADA and GE OMS platforms with the intention of not compromising data quality whilst facilitating this transfer. An ICCP solution was initially proposed by General Electric (GE) to facilitate this transfer. Subsequent correspondence with ACS indicated that the milli-second accuracy time-stamping eTE requirement was not supported by the ACS ICCP interface. It was also anticipated that significant losses in the data quality attributes may result when translating from DNP3 to ICCP. As a result, ACS proposed DNP3 level 3 compliant software RTU to facilitate this interface. The solution may be changed in the future to ICCP, however this is dependent on the Outage Management System (OMS) project requirements and the same architecture may still apply.

Virtual RTUs have to be created to represent each physical RTU on both the ACS and GE platforms. Each status point needs to be reflected on the ACS platform and the corresponding alarm needs to be confirmed on the GE side. The SCADA Alarm Reference guide should be used when alarms and limit alarms are being configured. There is also a need for analogue values for each station to be confirmed between the ACS and GE platforms. The control points will be confirmed directly by the monitoring of supervisory relays on-site.

The major concern is that Control Room Operators may be required to make use of two systems to execute their duties. However, if it is confirmed that the GE product provides a sufficient SCADA alarm banner and reporting tool, it may then not be required for the Control Room Officers to use the ACS interface. As there are two systems, it may be possible that different operators may be able to issue the same control instruction from the different interfaces. This is however unlikely, as only one control can be issued at a time as the select-before-operate interlock mechanism is incorporated at the RTU level. This ensures that only one user is able to take control of a particular device at any given time. The architecture overview for the ACS

OMS is illustrated in figure 3.10. Given the critical nature of the interface, a redundant architecture has been proposed.

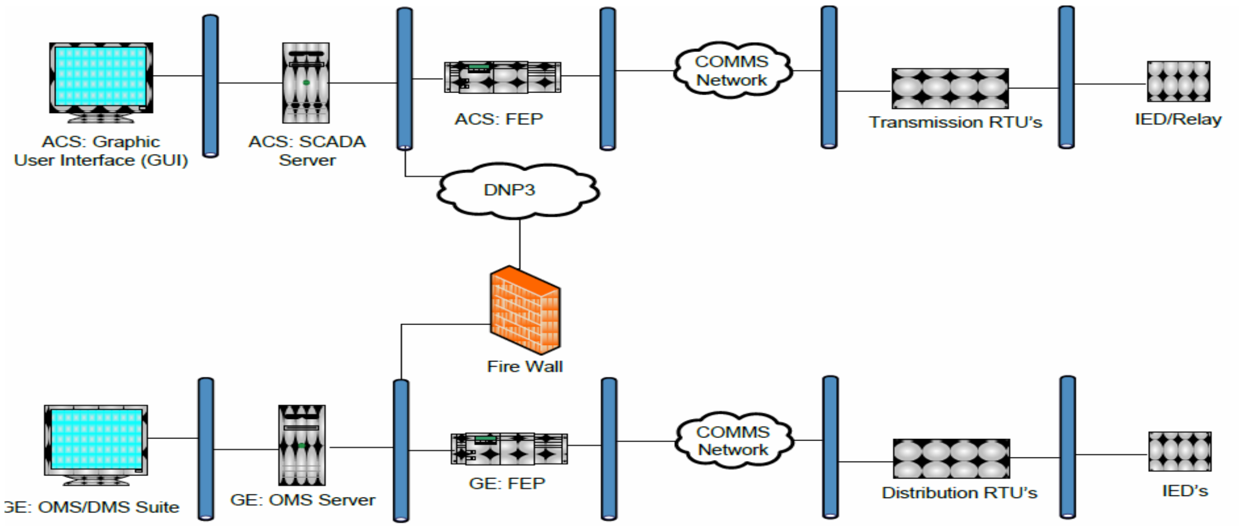

Figure 3.10: Architecture Overview for ACS OMS [20]

3.2.1.2 Advanced Control Systems (ACS) RTU Upgrade

eTE purchased 23 MPR-7010 RTUs from ACS in 1992, but have now reached the end of their life after over 20 years of excellent service largely due to new technological developments that have made the current deployment architecture of these RTUs obsolete. Research has shown that it will be technically and commercially feasible to upgrade only the communications and microprocessor cards on these units. The existing cabinet, field wiring and input/output cards are in a satisfactory condition and therefore do not warrant any replacement.

The proprietary protocol used to communicate to the legacy RTUs no longer conforms to the vision of the eTE in achieving its SG objectives. The major factors driving the upgrade are the availability of spares, application of ageing communications technology and standardizing on an industry protocol. A study concluded that the current communications method of Frequency Shift Keying (FSK) was outdated and based on old technology and that Internet Protocol (IP) technology should be implemented. The major benefit of IP communication include the ability for relevant staff to remotely conduct updates, configuration changes and remote diagnostics of faults without the need to physically drive to site, thereby improving the response times to faults. A pilot site of 2 months at the Old Fort Road substation yielded satisfactory results and it is being motivated to extend the upgrade to a further 22 substations.

The scope shall include the installation and commissioning of Connex30 upgrade kit for the MPR 7010 RTU at 22 sites. This will entail a complete audit of the tele-control system at the site including the updating of wiring schedules, master-station databases, single line diagrams, analogue limit alarms and the calibration of transducers. The critical path items shall include:

- Complete audit of the tele-control system
- The existing RTU has to be then decommissioned.
- Configuration settings for tele-control hardware and software
- Creation of master-station databases and single line operator diagrams
- Commissioning of status, telemetry and control points to the master station

3.2.1.3 CCTV Project

Security challenges are amongst the major concerns for most electricity utilities in South Africa and eTE is no different. The global demand for non-ferrous metals which has resulted in growing cable and conductor theft on electrical installation has topped most agendas of security concerns. The theft of electricity and increased incidents of vandalism compounds this problem even further. eTE has therefore embarked on installing certain security measures at their substations and these include the installation of electric fences, access control and CCTV surveillance systems. In 2010 eTE installed CCTV surveillance systems at six substations for evaluation purposes. This work has been completed and the intention is to appoint a contractor to undertake the design, supply, installation, testing and commissioning of the required CCTV systems at various other substations within the eThekwini area of supply.

The Scope of work shall include the installation and commissioning of master station equipment and 5 sites are currently being earmarked. The communications infrastructure was not capable of providing sufficient bandwidth for video surveillance and has therefore recently installed a DWDM network with a 1 GB channel dedicated for video surveillance. The critical path items shall include:

- Communication links to each site needs to be commissioned over the DWDM system.
- Fibre trenching and laying is necessary at each substation.
- DC power cabling and trenching is also required at each site.
- Commissioning of field equipment
- Commissioning of master station equipment

3.2.1.4 SCADA for 33 kV Substations

There has been a growing need to extend SCADA to the 33 kV portion of the electrical network and this need is driven from the various planning and operations departments, even though a plan is currently underway to replace all 33kV stations. Four sites have been chosen where SCADA services are critical. It was determined there would be a significant return on investment should SCADA be deployed at these four sites from the cost benefit analysis study.

This project entails the wiring of panels to a supervisory junction box, the procurement of RTUs and the installation and commissioning of the same. The critical path items include:

- Control systems to update existing plant wiring schedule.
- Contractor to wire panels according to specification
- SCADA to procure RTU
- Contractor to install, configure and wire RTU.
- DC Systems Division to run and terminate power cable.
- SCADA Division to create database and one line diagram.
- Communication Branch to provide communication links to each site over the WAN.
- SCADA Division and contractor to commission RTU.

3.2.1.5 Energy Management System (EMS)

In 2004, eTE purchased advanced application software licenses for the representation of the HV interconnected network in electronic format. These consist of advanced application licenses and include:

- Topology Processor
- DASMap
- RedHat Linux (ES-5, WS-1)
- Oracle (2)
- Web Portal

The hierarchical and interconnected layouts of the HV network was completed in 2006 and this will form the baseline on which the new model will be built on. The diagram can also be imported from ESRI-GIS if required. The aim of this project is to represent the HV network in electronic format. The introduction of advanced modules viz., Volt/Var Control, Dispatching, Switching, and Power Flow Analysis shall be considered as separate projects in future years. The pilot project shall incorporate 5 substations on the HV network. The critical path items include:

- Import/convert hierarchical diagram into the MAPDB (DASmap)
- Create a unique ID for all elements in the display
- Create working topology for the 5 substations from DASMap to PRISM.
- Update Device names to the 5 substations
- Update station/category/point to the 5 substations
- Complete the interconnected ring with relevant substations
- Provide a process document to complete the remaining sites
- Base DASMap training
- Standard DASMap training

- OJT training on the model
- Advanced DASMap training
- Adding blocks
- Adding layers
- Adding command targets
- Creating devices end to end

The main safety concern is the accuracy of the state representations. The mimic board and the software diagram will be operated and maintained concurrently until the necessary minimum confidence thresholds are exceeded.

3.2.1.6 Penetration Testing

eTE manages a SCADA network that controls and monitors the electricity supply within the area of supply. Most of the technologies deployed within the SCADA network are IP based and network availability and integrity is becoming a growing concern. The SCADA network interfaces to various business systems, a technical WAN, two APNs and the internet through a single public IP for remote VPN access. eTE has embarked on a project to address SCADA security concerns related to operational networks within the electrical environment. The organization has adopted the North American Electric Reliability Critical Infrastructure Programme (NERC-CIP) framework as a guide in deploying its security objectives. A phased approach will be adopted and the project will be broken down as follows:

- The first phase involves non-intrusive penetration testing.
- The second phase shall involve conducting an audit in accordance with the NERC requirements and developing a gap analysis and implementation plan.
- The third phase shall involve implementation of the recommendations. A philosophy of continuous improvement shall be implemented with compliance to NERC-CIP.

The aim of this phase of the project is as follows:

- To identify current external network attack vectors
- To identify high and low risk vulnerabilities that may be exploited
- To provide evidence to support further investment in security personnel and technology.

It is therefore imperative that non-intrusive penetration tests be conducted on the SCADA network. The service provider must adopt and adhere to the Open Source Security Testing Methodology Manual (OSSTMM) rules of engagement, specify the process adopted and tools used for the testing, and provide a timeline estimate to conduct the penetration tests. The limits of testing are set out below:

- Obtain privileged access to servers

- No drill down on any server required
- No exploitation of any vulnerability
- Only non-intrusive testing may be conducted.

3.2.1.7 Phasor Measurement Units (PMU)

With eTE's ever increasing and evolving network, there is a vital need to have real time monitoring of the network. Synchro PMUs (SMUs) are usually considered as a technology to monitor the network and manage consumer demand. The system comprises of a Phasor Measurement Unit (PMU) that works in conjunction with other Intelligent Electronic Devices (IEDs). Three conceptual designs will be presented in this section, two of which are the VectoGraph and ImpedoGraph systems which form part of the legacy system for fault recording and system monitoring. The newer system of synchrophasor measurement technology (SMT) is also presented and compared to the older systems. SMTs will aim to provide real time monitoring of eThekwini's electrical network with improved stability, security, performance and is a key component and enabler of a SG system. Significant improvement may be achieved in the following areas by making use of SMTs: [21]

- Network visualization in real-time
- Outage Analysis
- Validation
- Benchmarking
- Improved state estimation
- Congestion management.
- Frequency and voltage stability monitoring

Interoperability of a system is the ability of all SG devices to be able to work together towards improving performance, reliability, security, stability and safety of the grid. eTE has already rolled out projects that support the SG initiative. The implementation of SMTs onto the grid will therefore promote interoperability within the projects such as ADMS, GIS and DIgSilent. VectoGraphs, developed by CTLab was the previous system used for disturbance monitoring and fault recording. It provides non-real time monitoring in 28 seconds intervals. ImpedoGraphs, also developed by CTLab is the other previous system used for disturbance monitoring and fault recording. It provides non-real time monitoring of voltage and current magnitude in 10 seconds intervals. SMTs provide real time monitoring of current and voltage magnitude and phase at a sample rate of 128 samples per second. Table 3.1 shows a comparison between SMTs and the conventional Vectographs. SMT provide a new method for improved protection, monitoring, control and visualization of wide-area system conditions. The use of real time voltage and current phasors will allow operators to have an overall picture of system performance at any given time. Based on the comparisons and a comprehensive study that was carried out, it is clear that SMTs provide superior solutions. It will improve system performance of the network through wide area monitoring, protection and control. SMTs are key enablers of wide area monitoring protection and control (WAMPAC) which is a backbone of SG systems. It will also allow eTE to meet NERSA's standard of providing power quality data to customers in real-time.

Table 3.1: SMTs versus Vectographs [21]

Options	**Option 1 (SMT's)**	**Option 2 (VectoGraph)**	**Derivables**
Sample Rate	128 samples per second	28 samples per second	SMTs will improve resolution as it has a higher sampling rate.
Availability of Data	SMTs will be connected directly to eTE network.	VectoGraph is deployed through a 3rd party network and there is latency associated with it.	It offers real time data streaming to network. This will help with real time wide area picture of network
Real Time Data	SMTs provide real time data of current and voltage phasors	VectoGraph provide non -real time voltage magnitude data.	SMTs allow event playback which could be used for RCA...
Wide Area Visibility	SMTs will allow eTE network to have integrated real time readings from across the network	VectoGraph gives instance of fault at a certain location.	SMTs allow wide area monitoring which will help operator with system operation in real time.
Voltage and Current Magnitude and Phase	SMTs through use of PMUs provide real time data of current and voltage phasors	VectoGraph provide non – real time voltage magnitude data.	Time data streaming will help with power factor and reactive power.
Time Stamped Data	SMTs through use of PMUs provide real time, synchronized time stamped data.	VectoGraph provides non-real time and it not synchronized.	Real time data will improve state estimation and assist in post- mortem.
Interoperability with Business Tools	DigSilent Power factory supports PMUs	VectoGraph is not supported by DigSilent	SMTs are interoperable with existing business tool.

3.2.1.8 Future Projects

Numerous future projects are earmarked for eTE in this particular area. Below is a list of projects earmarked for implementation:

- Process Bus at HV substations

- FDIR at key locations
- Real-time DA database
- Loss Minimization
- Voltage Control / Regulation
- Integrated Volt / VAR Control
- Loading Relief
- Micro-grid Control
- Load Estimation
- Three Phase Unbalanced Distribution Load Flow / System Analysis
- Short Circuit Analysis
- Protection Coordination on the operational network
- Contingency Analysis
- Load Forecasting
- Real-time Study Mode Analysis

3.3 Summary of Chapter

The organizational structure and operations at eTE is currently classified according to the various voltages levels and the operation is hence broken up into the HV and MV/LV departments. DA is one of the main focus areas of SG as it has the most visibility in terms of its applications as it in an operational environment. Various projects are underway at HV and MV/LV level and some of the benefits of these SG systems are now being realized by the organization. eTE has invested a lot of funds and resources into SG related activities and the flagship project is the rollout of the OMS/ADMS initiative.

Chapter 4

DISTRIBUTED GENERATION

4.1 Summary of DG at eTE

It is quite clear that Distributed Generation (DG) and SGs are and will become more a part of the world's future and energy storage will be a critical element of this. The acceptance of this and the change in mindset will fundamentally change the way consumers procure and control their energy. Consumers worldwide are turning to DG in various forms, with energy storage as a key consideration for the future.

IEEE defines DG as "generation of electricity by facilities that are sufficiently smaller than central generating plants so as to allow interconnection at nearly any point in a power system."[5]. The interconnection of DG sources onto the electrical network is currently classified as one on the methods that a utility can demonstrate as implementing SG systems. The eThekwini Municipality has embarked on many such projects, some from a municipal perspective and others restricted to the Electricity Unit. The most significant project was eThekwini's Landfill Gas project which was the first of its kind in South Africa and went live in 2006. This project shall be discussed in more detail later in this chapter, along with 2 other major projects.

Current DG projects at various eThekwini sites potentially generate approximately 10MW and as indicated in table 4.1.

Table 4.1: Current DG Projects at eTE [23]

Current DG Project	Generation Capacity
Marianhill Landfill Site (LFS)	1 MW
Bisasar Road LFS	6.5 MW
Dube Tradeport Photo Voltaic (PV)	0.5 MW
Hazelmere Concentrated PV (CPV)	0.5 MW
Vertical Axis Wind Turbine (VAWT)	30 KW
Co Generation (Tongaat-Hulett)	1 MW
Total	**+/-10 MW**

Future DG projects earmarked for eThekwini which could potentially generate approximately 81.3 MW are shown in table 4.2.

Table 4.2: Future DG Projects at eTE [23]

Future DG Project	**Generation Capacity**
Wind Generation	300 KW
Hydro	8 MW
Gas Peaking Plant	42 MW
PV	14 MW
Landfill Gas	2 MW
Waste Water Works: CH_4	8 MW
Mini Hydro	1 MW
Ocean Current Generation	6 MW
Total	**81.3 MW**

Amongst others, factors that affect the impact of DG are:

- Energy conversion method
- Generation plant location
- Export capability
- Impact on fault levels
- Protection systems
- Synchronization
- Generator control method
- Source of fuel
- Loading of network

4.2 Flagship DG Projects

4.2.1 Landfill Gas Project

The first phase of eThekwini Municipality's project to generate electricity from landfill gas became operational in December 2006. The project was largely aimed at addressing global warming and climate change which are serious environmental issues facing the world [22]

On the Marianhill site a 1000 KW machine was installed and provision was made for a second machine. At LaMercy a 500 kW machine was installed and the gas supply allowed an 8MVA generation capacity at the Bisasar Road site. The aim of this project was to destroy methane in engines and this system has had a 99% success rate to date in terms of effectiveness. It was also projected that eTE's electricity to Eskom would be reduced by up to 10MW when all three sites became operational and would result in approximately a 450 000 ton reduction in CO_2 emissions.

The publication of the REFIT tariff by NERSA in April 2009 of 90c per kWh for landfill gas projects made all three sites viable on the sale of electricity alone. The physical layout of a typical landfill gas generation site is illustrated in figure 7.1.

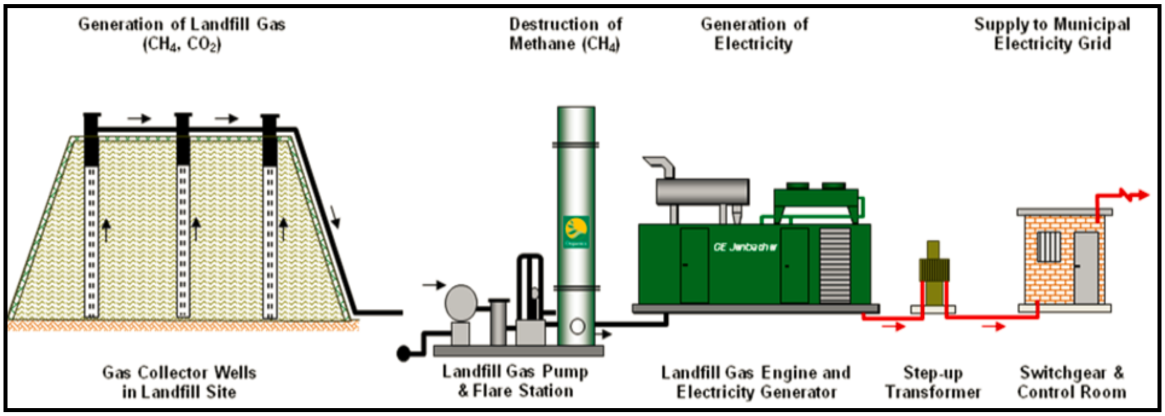

Figure 4.1: Physical Layout of Landfill Generation Site [22]

The first major challenge arose when eThekwini's local 11kV network was found to be causing un-necessary tripping of the 11kV breaker feeding the generator, when out of zone earth faults were detected. After numerous investigations, it was decided to install neutral earthing resistors on the star point of the 440/11kV delta/star generator transformer. These false trips then required 11kV authorized field staff to visit site and manually close the circuit breaker, resulting in increased operational costs.

The Alternators supplied are Stamford PE734C, four pole; lap wound brushless synchronous AC generators. The data sheets supplied indicated a rating of 1550 kVA at 400V and 50Hz, with a continuous rating H -125/40 deg C, 1240 kW at an efficiency of 95.9% with a mechanical input of 1293 kW. This detail could become important during the CDM verification phase where every kWh loss component is carefully monitored. Fault level contributions into the local network from the generators and quality of supply issues are key considerations. The data sheet indicated a fault current of approximately 10.2 kA at 400V. The worst case scenario yielded a fault level of 7.8 MVA at 0.9 pf lagging at 400V at the generator terminals. After the 1MVA, 6.6% impedance, 400V to 11KV transformers used to connect each machine to the 11kV council network, the fault level had already dropped to just over 5MVA per machine (at 11kV) at the point of common coupling. Taking into consideration that eTE designs the 11kV network for a fault level of 350MVA (derived from 2 X 30 MVA, 16.9% impedance transformers in parallel fed from the 132kV network) the total fault level from the Bisasar Road generation site at full capacity of 8MVA yielded only a 40MVA fault level, and therefore did not significantly affect equipment rating [22].

It also became clear that that gas supply for the engines required a great degree of monitoring and control. While all the initial calculations had shown sufficient gas at Marrianhill site to supply a 1MVA machine, in the first 3 months it was found that the gas supply was unstable. If too much of gas was extracted from the field the oxygen level rose above 5% and the machine tripped on gas safety. The 1000 KVA generator then had to run at 600 KVA for the first 4 months to allow the gas field to stabilize. This output had then been increased to 900KVA and the site was closely monitored. At the LaMercy site the gas was found to be too “wet” and engine performance was very erratic.

A monthly average of 420 000 kWh of electricity was generated at the Marrianhill site, which had saved eThekwini approximately between R60 000 and R80 000 per month. The first 4MVA installed at Bisasar Road generated 100MWh per day which equated to R240 000 per month during the low season months and projected in excess of R 1 million per month when the REFIT rates of 90c /kWh were applied [22].

The first 4MVA at Bisasar Rd site was commissioned in early 2008, and a further 2MVA was commissioned in May 2009. The La Mercy engine was moved to Bisasar Rd taking the installed capacity to 6.5MVA. Many of the lessoned learned during these pilot projects have been applied and this site experienced above 95% availability of the generators in the first 12 months of operation. The 2008 figures from Bisasar Road site have shown that on average a landfill gas to electricity site costs in excess of $1 million per MW installed capital cost, and approximately R200 000 per month operating costs for a 4 MVA installation [22].

Figure 4.2 depicts a general layout of the Landfill DG arrangement and the net effect of inserting a Neutral Earthing Resistor (NER) into the circuit. The NER reduces the fault level from 59.968 MVA to 3.873 MVA and the fault current from 3095 A to 203A.

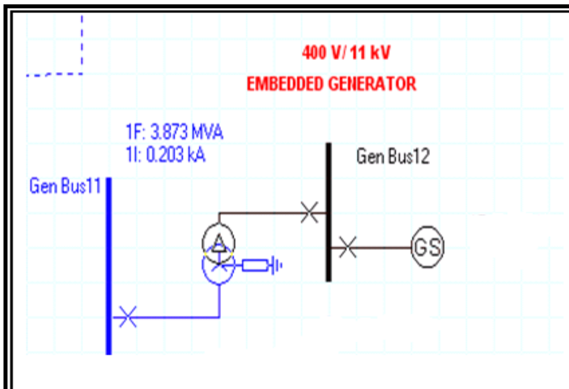	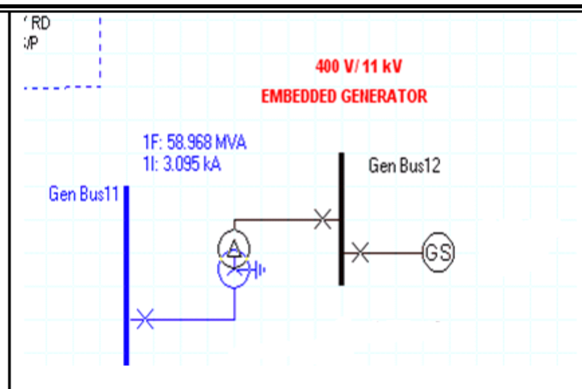
8 MW Landfill gas to Electricity DG with NER (Earth Fault Current contribution 203A from the Generators)	8 MW Landfill gas to Electricity DG without NER (Earth Fault Current contribution 3095A from the Generators)

Figure 4.2: Schematic Layout of DG [23]

4.2.2 Concentrated Photo Voltaic (CPV)

The eThekwini Municipality had made an application for funding to the National Department of Environmental Affairs (DEA) for a Photo-Voltaic (CPV) power plant project [24]. The application was for the electrical infrastructure and made mention of a proposed solar power plant that would be located within the municipality and be a high profile project which would showcase the municipality's commitment to meet renewable energy targets.

The South African Government's Inter-Ministerial Committee (IMC) on the 17th Conference of the Parties (COP17) had endorsed the eThekwini Solar PV Flagship project and had tasked the DEA to support the eThekwini Municipality in ensuring the project is operational for COP 17, which was held in November and December 2011.

Triple-junction, high-performance solar cells similar to those utilized for power satellite applications are used for the CPV system The conversion efficiency of the triple junction cells is approximately 40%, which is far superior that of conventional solar cells. It was a requirement that the CPV modules must be perpendicularly aligned to the sunlight on a 24 hour basis so that the light could be directly concentrated onto the cells. It was proposed to install 34 CPV units which could produce a maximum of 500 kW.

Electricity produced by the CPV units is transmitted via DC cables through the tracker controller box. The CPV system consists of a 15 kW string inverter at a voltage of 440 V_{ac} and will be connected to a field distribution box where electrical current will be routed to a main distribution board. The electricity supply will then be routed to a step up transformer, which will increase the voltage to 11 kV. Figure 4.3 illustrates the layout of a typical CPV arrangement.

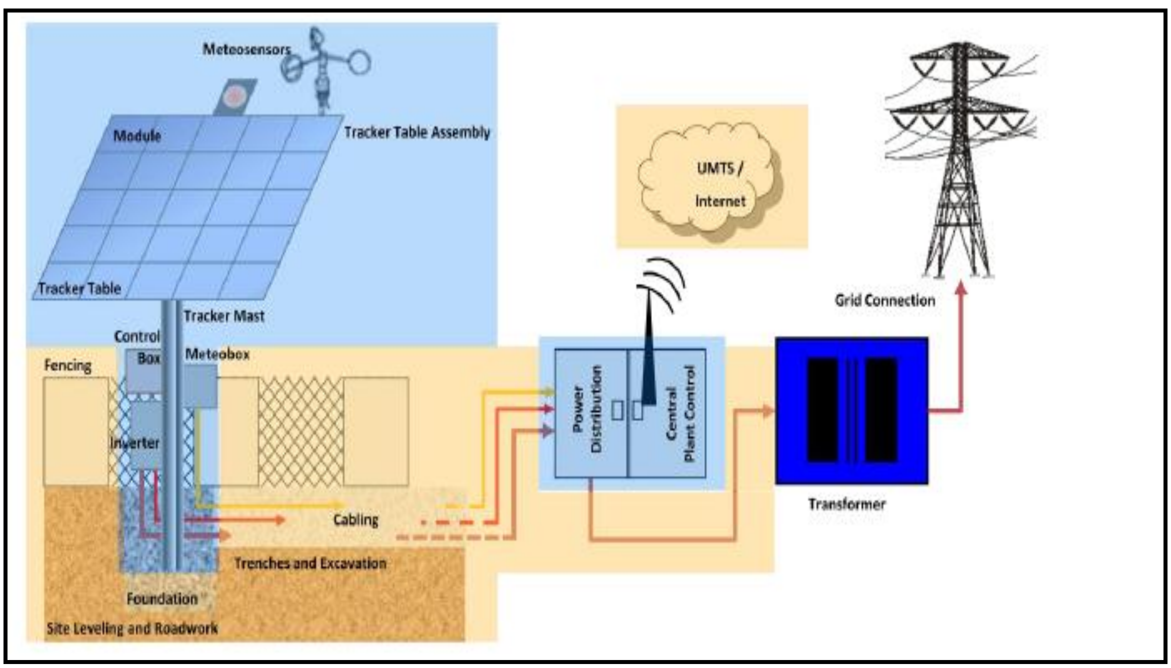

Figure 4.3: Layout of CPV Arrangement [24]

Johnson Control Industry (JCI), a Soitec partner, provided the operational and maintenance services which were necessary to provide uptime with guaranteed performance. JCI had also established a standing operations schedule to ensure performance of all scheduled and non-routine work that was required to operate and maintain the independent utility plant and the building's mechanical, electrical, plumbing, security and structural systems.

The environmental benefits of the project are as follows:

- CPV is environmentally friendly as it has minimal impact on the fauna and flora.
- Requires relatively small quantities of water to clean.
- The temporary shade it sheds during certain times of the day promotes the return of indigenous vegetation in areas with extreme temperatures where the land was damaged by imprudent use.
- According to the glare test report compiled by a test lab in Germany, the glare caused by the CPV modules is less than that of a glass window. Glare of a plain glass window is used as a bench mark by airplane pilots.

The socio-economic benefits are as follows:

- Cleaning of the panels is labor intensive and provides for permanent job opportunities.
- Soitec will implement training on-site with staff and other candidates as provided by the municipality. Furthermore, Soitec will develop, together with a leading university and college in South Africa, a training curriculum to train people with different levels of qualification in KwaZulu-Natal.

The breakdown of the electrical infrastructure costs are detailed in table 4.3.

Table 4.3: Electrical Infrastructure Cost Breakdown for CPV Project [24]

Item Quantity	**Total Cost (Including VAT)**
Material Cost	R 355 606.47
Resource Cost	R 89 898.51
Equipment Cost	R 31 532.99
Geotechnical Studies	R 25 000.00
Water Infrastructure Installation	R 15 000.00
Sub Total	**R 517 037.97**
Academic Curriculum Cost	**Total Cost (Including VAT)**
Basic Level (unskilled)	
Specialization Level (semi skilled)	**R 350 000.00**
Post Graduate Level	
Total	**R 867 037.97**

eTE had requested support from the DEA to fund the electrical infrastructure of the concentrated solar photovoltaic power plant project for the COP 17 event and the training program for eTE's staff members to facilitate skills transfer based on a cost breakdown as itemized in the summary above.

Figure 4.4 shows an anticipated generation profile of the CPV that was used for this project compared to a conventional thin-filmed CPV. It can be seen that there is superior generation capabilities throughout the day with the implemented system.

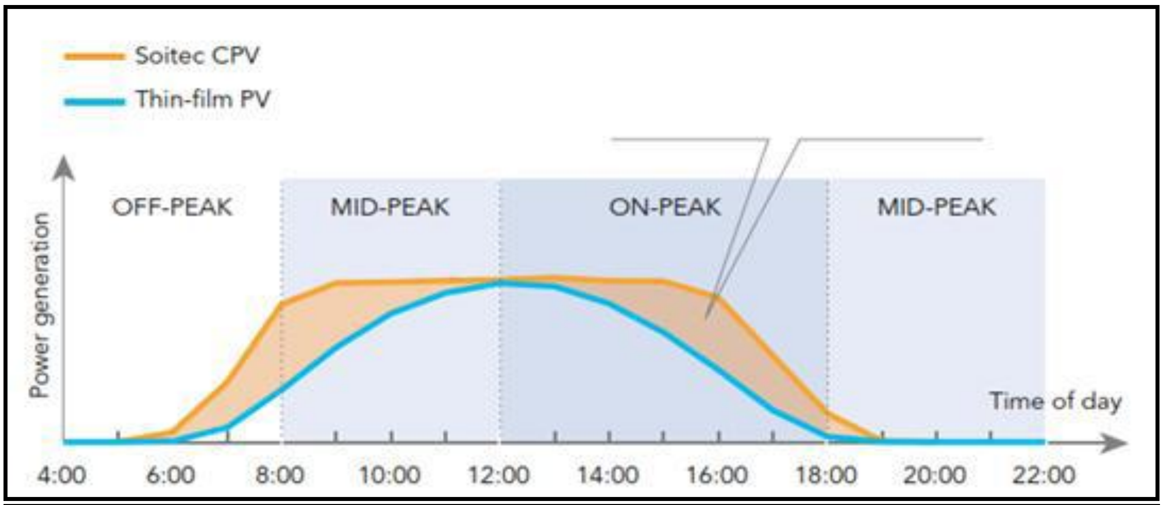

Figure 4.4: Soitec CPV versus Thin-film CPV [24]

4.3 Summary of Chapter

The current energy crisis and the global demand for electrical power have placed a lot of strain across electrical networks, worldwide. The interconnection of network between countries for the import and export of power is being thoroughly explored to assist with this challenge, however the implementation of DG projects have been assisting with this challenge, albeit on a much smaller scale in SA. eTE has and is exploring at DG options that are practical and realistic from a municipal perspective and have embraced the concept and have accepted projects that are not municipal initiatives. The licensing of these generation sources and legal issues still remain a major challenge in this area. The major projects that stand out for the eThekwini Municipality are the landfill gas projects and the photovoltaic solar farm project.

Chapter 5

ETE SMART SYSTEMS AND ASSET MANAGEMENT METHODOLOGY

5.1 Smart Street Lighting

5.1.1 Overview of Street Lighting at eTE

The street lighting at eThekwini Municipality currently accounts for approximately 3% of the total electricity consumption of the city. The current national energy crisis and the ever increasing need for energy efficiency calls for innovative solutions across all sectors to assist with reduction of the national electricity demand. The municipality previously used the traditional lighting technologies, which are high-pressure sodium vapor (HPS), high-pressure mercury vapor (HPMV) and metal halides (MH) lamp technology. These technologies are known to be very effective for their applications but however, consume significant amounts of energy, pose environmental and health concerns, require significant maintenance and need to be replaced at periodic intervals. The municipality is therefore continuously striving in assessing innovative potential solutions to better manage its electricity demand, to reduce long-term costs and maintenance and to minimize environmental and health risks {34].

The two main interventions that eTE has implemented to support the SG objective is the implementation of light emitting diode (LED) street lighting and the rollout of a lighting telemanagement project. EThekwini had carried out various projects that compared the various lighting technologies which included sodium, mercury, metal halide, induction and LED. LED technology provided satisfactory results and the city also received grant funding from various sources to specifically implement LED street lighting. These funding sources included foreign sources that were Danish, Swiss and German as well as local funding from the Energy Efficiency and Demand Side Management (EEDSM) initiative via the Department of Energy (DoE).

EThekwini aims to implement Smart Street Lighting, the benefits of which are stated below:

- Enables smart cities
- Advanced monitoring
- Remote control
- Reduce maintenance costs
- Reduced energy consumption
- Improve information availability
- Reduced greenhouse gases
- Improve customer satisfaction

5.1.2 Evolution of Lighting

The illustration in figure 5.1 is a summary of the various technologies used in lighting applications. It also includes a comparison of the progressive luminous efficacies (Lm/W) of the various technologies since 1920. It can be seem that MH and HPS are currently superior in this regard but LEDs are making rapid progress and are soon projected to take the lead.

It must also be noted that there is a national and global drive to gradually phase out inefficient light sources such as incandescent and mercury lamps. This is largely driven by their impacts on energy efficiency and on the environment. It is also projected for LED technology to push the lighting market towards greater efficiency.

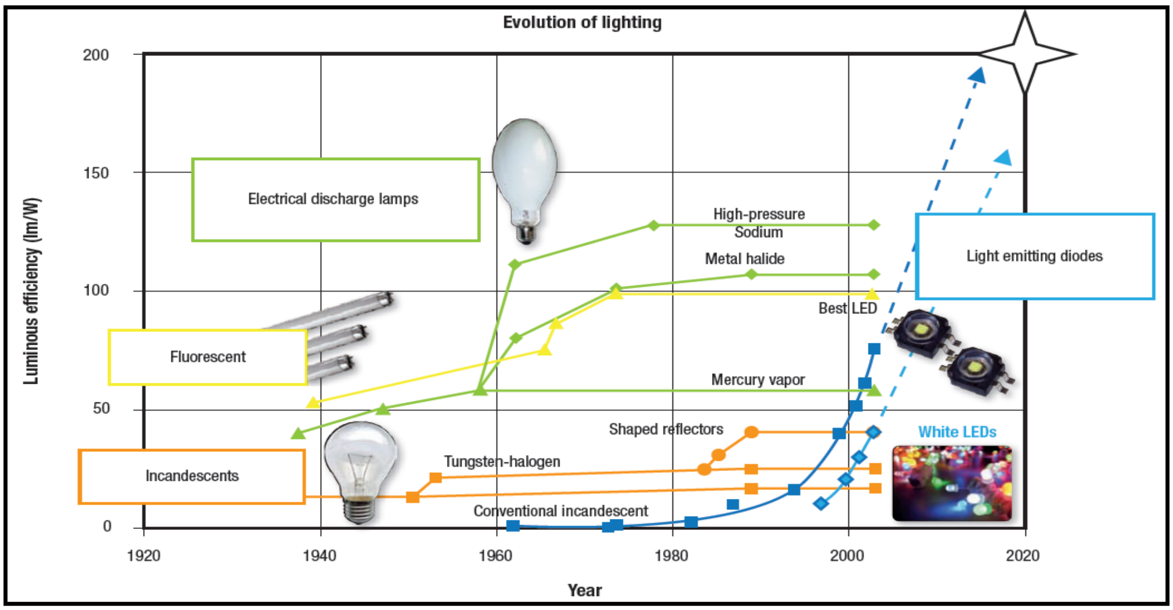

Figure 5.1: Evolution of Lighting and Luminous Efficacy [25]

5.1.3 Light Emitting Diodes (LED)

The use of LED for various applications has increased exponentially over the past few decades and is even being hailed as the future of lighting by many. The suppliers and manufacturers are claiming various advantages which include a compact size, longer life spans, lower maintenance, improved design capabilities, color rendering features and increased luminous efficacies, amongst others. LEDs are changing the tradition of photometry and are being continuously improved to maximize benefits.

The benefits of LEDs are as follows:

- Lower energy costs

- Reduce power consumption
- Improved controllability
- Improved lumen constancy
- Longer life
- Predictable life span
- Redirection of light emissions
- Improved reliability
- Environment friendly
- Quick turn on/off
- Dimming capability

All LED street light projects that have been implemented at eTE are detailed in table 5.1. It can be seen that the energy savings are quite significant over a relatively short period of time. These readings were extracted over a period of 12 months for the 2013/2014 financial year. It must also be noted that the 80W HPMV replacements ranged from 30 to 66W "equivalents", the 150W HPS replacements from 72 to 106W LED "equivalents" and the 250W HPS replacements from 148 to 204W "equivalents". These figures and comparison are based purely on energy consumption, however a more intense study is required to compare full life cycle costing.

To put this into context, the following needs to be considered:

Annual Street Lighting Consumption: 32 MVA
eThekwini Maximum Demand: 1828 MVA

In the past financial year, street lighting therefore accounted for 1.75% of eThekwini's total electricity consumption.

Table 5.1: eTE LED Projects Summary [34]

	Quantity	HID Energy Consumption (KWh)	LED Energy Consumptio n 9KWh)	Energy Saving (KWh)	Cost Saving (R)
80W HPMV Replacement	4386	1536854.4	1137385.3	399469.14	R519 150.09
150W HPS Replacement	1324	1038042.5	504978.96	533063.52	R692 769.35
250W HPS Retrofit	1120	878102.4	530891.04	347211.36	R451 235.88
Total	6830	3452999.3	2173255.3	1279744.02	R1 663 155.32

5.1.4 Lighting Telemanagement System

EThekwini is currently in the process of rolling out a lighting telemanagement system. A pilot project for the implementation of an Owlet Telemanagement system for 20 light fittings on Umgeni Road is currently underway. The cost of the project is R200 000. The benefits of telemanagement are summarized below:

- Dimming capability
- Adjustable on/off timing
- Lamp failure detection
- Energy consumption monitoring
- Open circuit detection
- Lamp-burning hours monitoring

The Owlet lighting telemanagement system is used to manage, control, monitor and meter outdoor lighting systems [26]. The main objectives of the system are to reduce greenhouse gas emissions, reduce energy consumption, improve reliability and minimize maintenance costs. Individual lighting points can be controlled and the system is based on open technologies. A central repository collects and stores date and time stamped critical information such as energy consumption, operating states and failures which could also be geographically categorized. The layout of a street light management system is illustrated in figure 5.2.

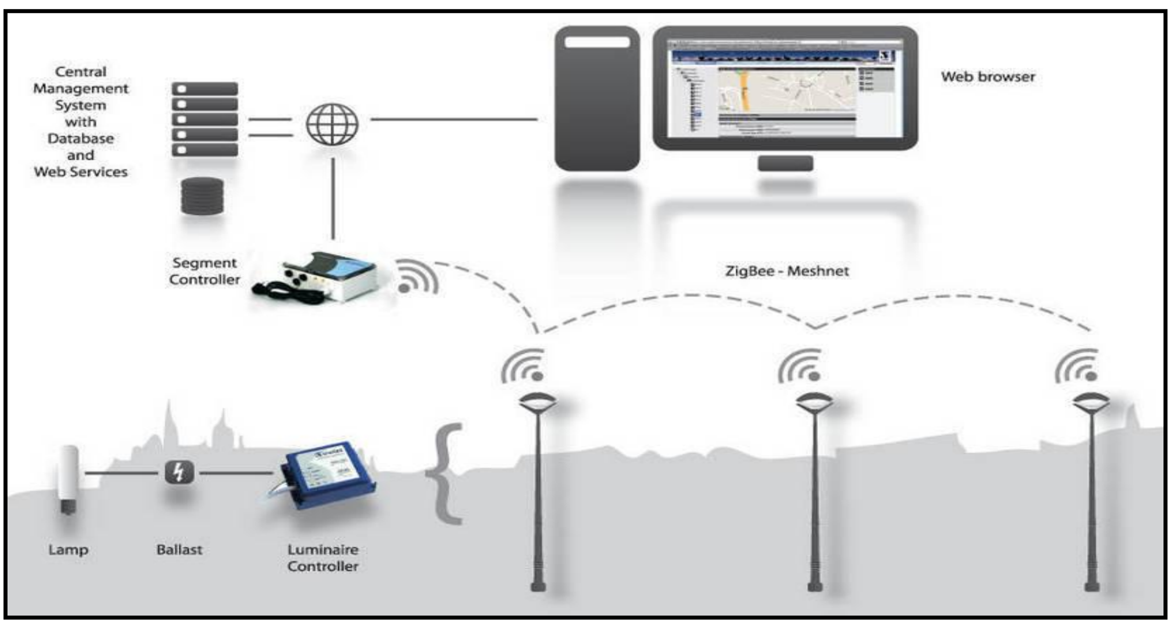

Figure 5.2: Layout of a Street Light Management System [26]

5.1.4.1 Owlet Nightshift Benefits and Energy Savings

Constant Lumen Output (CPO)

This could result in a saving of between 8 to 10% energy saving. Lighting designs usually take a maintenance factor into consideration which allows for a reduction of luminous flux over a period of time so that the illuminance requirements could be met. To ensure that lighting levels do not exceed the minimum levels during inspection and maintenance intervals, newly installed lamps would therefore emit more lights that initially required. The reduction of excessive lighting and the depreciation of light output are compensated for by this CPO function [26].

Virtual Power Output (VPO)

An energy saving of up to 25% could be achieved. Industry standards dictate that lamps are made available by manufacturers and suppliers in a range of fixed wattages. Power requirements are determined by factors such as pole spacing, uniformity ratio and lighting level requirements. The exact calculated value very often results in a value that falls in between fixed wattages available so this usually results in over designing of the lighting system. The VPO function allows for dimming to the calculated value thereby saving energy [26].

Selective Dynamic Lumen Output

A projected energy savings of between 30 to 40% could be achieved. This function allows you to adjust the lighting level in relation to the traffic flow and density. Dimming profiles could be defined as per the requirements at any given point in time [26].

System Architecture

The lighting installation could be managed, monitored and controlled from any remote location. The use of open system allows the user not to be locked in to a particular vendor and have the flexibility to use industry available technologies. The core of the Owlet system is a wireless mesh networking technology which is the open protocol Zigbee and complies with IEEE 802.15.4 industry standard [26].

5.1.4.2 System Components

Column Controller (CoCo)

Independent supply points and individual metering is catered for especially for applications with multiple loads such as advertising and decorative lighting, etc. There is also continuous monitoring and logging of critical parameters such as power factor, current and voltage. Provision is also made for an astronomical clock [26].

Outdoor Luminaire Controllers (OLC)
The various configurations of the CoCo and OLC share the Zigbee communication, lamp detection function as well as switching and dimming capabilities. The outputs are rated at 1KW at 230V and magnetic, bi-power and electronic ballasts as well as LED drives are supported by the OLC [26].

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Luminarie Controller (LuCo)
This is normally the preferred option where the system is integrated into the luminaire. Either an option with a DALI interface, integrated energy meter or a pillar mounted common meter could be used. There is also continuous monitoring and logging of critical parameters such as power factor, current and voltage. Provision is also made for an astronomical clock [26].

Segment Controller (SeCo)
The SeCo is a series controller and manages a grouping of CoCo´s and LuCo´s. Collection of data is achieved through the OLC which is routed through the ZigBee network and transmitted to the Webserver over the internet through a secure VPN. Provision is made for two analog and two digital input and output modules as well as a Modbus Interface. The grouping of lighting circuits or categories could also be programmed to enable synchronous operation, where required [26].

5.2 Smart Metering

The reading of meters and the production of accurate bills still remains a major challenge for municipalities in South Africa. SM systems could therefore be leveraged to provide timeous billing, accurate meter readings, validation, estimation and the ability to remotely connect and disconnect circuits. It could assist utilities in reducing energy loss, improving distribution network management, identifying network problems, planning upgrades, maintenance planning, improving revenue collection processes and reducing revenue losses. It will also promote customer interaction and the drive to improve energy efficiency by keeping them continuously informed.

It is sometimes extremely difficult or impossible for meter readers to access the premises of customers, which either results in no readings or estimated consumptions on the customer's bill. SM system could, however validate consumption data and correct any inconsistencies via the Meter Data Management System (MDMS) before the data reaches the billing system. The editing and validation functions enable effective management of consumption levels, which eliminate cases of readings not being recorded because of meter failure and energy theft which usually result in meters being bypassed. SM systems could also work in conjunction with existing revenue protection systems to minimize the impact of revenue losses. SM systems could continuously monitor meters and provide reading validation, estimation and editing to detect anomalies, evidence of tampering, alarm generation, energy balancing and initiate nonpayment or tamper disconnection, which could eliminate the need site visits and audits.

5.2.1 SM Rollout at eTE

eThekwini is currently in the process of rolling out a modern SM system. It has engaged the consultancy services of Accenture to assist with this process. A summary of the programmes, action items and some of the achievements to date are listed below: [27]

- Establishment of an Advanced Metering Infrastructure (AMI) Programme
- Customer Marketing and Stakeholder Plan
- Implementation Plan
- Business Case benefits identification
- Solution Conceptual Blueprint
- Smart Meter Operational Centre (SMOC) Support Structure defined
- AMI related As-is Business Processes documented
- 4 (Request for Proposals) RFPs issued to the Market (Metering Devices, MVMS, MDMS, Field Installation)
- User Cases (requires product vendors input to finalize)
- Design of manual business processes
- Customer Communication Approach and Plan

The next steps are as follows: [27]

- 4 RFP Evaluation and Contracting
- Vendor Solution Design Implementation and Integration
- Solution Training
- Customer and Stakeholder Communication
- Field Deployment (~10,000 installations)
- Technical Infrastructure Finalized
- Systems Implementation
- Automated Smart Meter Billing
- Rapid Field Deployment (Remaining meters)
- Middleware to support first phase functionality
- Rollout of remaining capability enabled through automation

Figure 5.3 shows a basic layout of the proposed eTE SM system from the backend system to the residential consumer. The system comprises of the wireless network for Global System for Mobile (GSM) communication or data concentrators for PLC (PLC) systems, an Authenticated Private Network (APN), meter integration, the Multi Vendor Metering System (MVMS) module, master station integration with the MDMS, an enterprise integration bus and the eTE backend system.

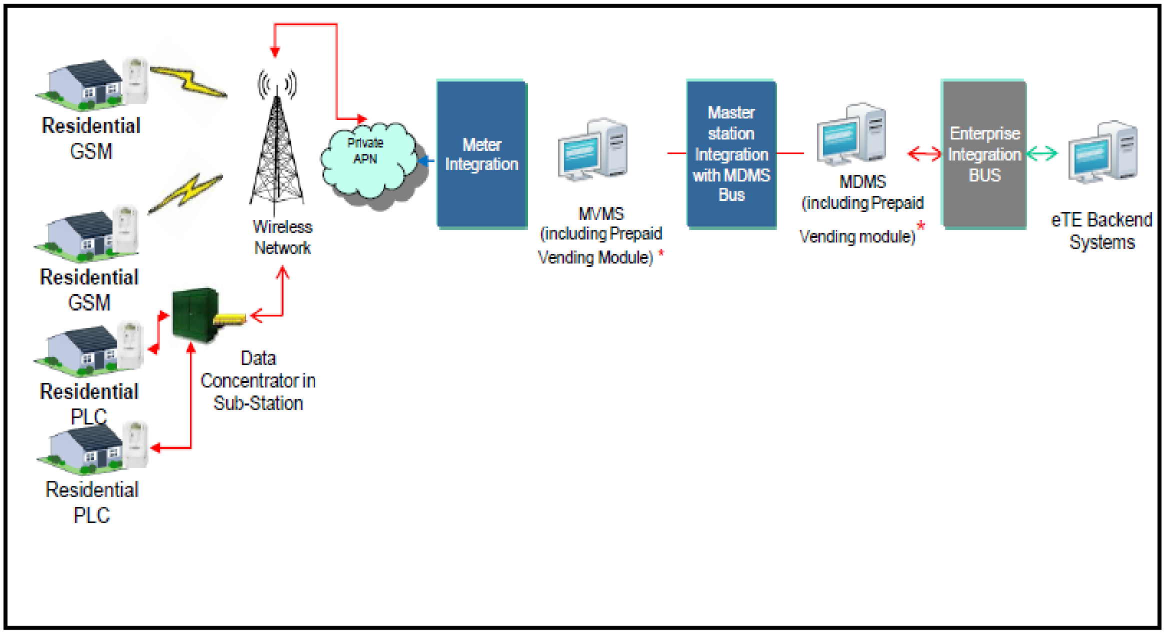

Figure 5.3: Layout of eTE SM System [27]

Table 5.2 is a summary of the AMI use cases and capabilities of the system. The list covers the basic requirements of eTE and the requirement capabilities will be reviewed with product updates and technological advancements in this field.

Table 5.2: AMI Use Cases and Capabilities [27]

Name	Description
AMI Equipment Registration	Remotely discovering and incorporating AMI equipment (concentrators, meters, customer interface units, measurement units and appliance control devices) into the AMI platform.
Remote Tariff programming	Remotely programming parameters related to tariff, registers, calendars and power limit. Support for advanced tariffs shall be supported, e.g. time of use (TOU), bi-directional, etc.
Meter reading (On demand)	Gathering and providing on demand meter readings for a specific request.
Meter reading (for billing)	Gathering and providing meter readings for the customer billing process (cycle reading).
Remote Disconnection and Reconnection	Remotely disconnecting or reconnecting the electrical supply of a customer by activating a contactor within the meter.
Load limiting	Activating or deactivating the demand control of the meter (load limiting) on demand or scheduled.
Alarm and event management	Management of events and alarms from the operation of the AMI equipment.
Outage information	Obtaining power interruption information.
Fraud/Tamper detection	Detection of any possible fraud or tamper events.
Remotes Access of Data Concentrators	Remotely registering, programming, reading and updating concentrator firmware
Load Profile Management	Remote programming and subsequent gathering of the load profiles registered by the meter.
Automatic Network adaption	Process of AMI equipment to automatically adapt to changes in the AMI network.
Energy balancing	Determination of energy balancing within the AMI network.
Customer device management	Sending specific messages to specific customers or group messages to group of customers.
Power Quality Management	Gathering power quality measurements from the AMI system.
Prepayment	Managing the prepayment functionality and switching between conventional and prepayment modes of operation.

5.3 Asset Management Principles

5.3.1 Overview of AM at eTE

eTE has developed an AM Policy and Strategy which is applicable to the Electricity assets of the eThekwini Municipality and includes transmission, sub-transmission and reticulation assets. These have been developed with due consideration of statutory and legal requirements, organisation goals as well as stakeholder requirements. eThekwini has been assisted largely in all processes relating to AM by Pragma, which is a consultant company specialising in the field of AM. This aggressive drive will immensely assist eThekwini in achieving its SG objectives.

The policy is largely based on Pragma's definition of the elements of AM and the levels of maturity to be achieved. This is defined by the 17 elements of AM, which form the framework of the AM policy and strategy. The policy is also aligned with the guidelines of PAS 55: 2008 "Specification for the Optimised Management of Physical Assets". [28]

A key aspect of the AM Initiative was the asset field verification and identification which was primarily conducted to comply with the Generally Accepted Accounting Practices 17 (GRAP17) financial regulations. This exercise, however also contributed to the enablement of AM fundamentals by providing reliable and detailed asset information. The captured information will be stored against an equipment hierarchy that will link the technical equipment register to the financial asset register and thereby enable transparent transactions of new additions, operations, maintenance and disposal thereby promoting more informed decision making.

The AM Policy seeks to address various concerns within the organisation. Losses and maintenance expenditure are of paramount importance in the development of the existing and future policies. In order to meet the goals and expectations of their stakeholders, the assets at eTE must perform in a manner that is safe, cost effective and reliable. It is therefore necessary to align to a carefully laid out framework in order to manage the AM functions effectively.

All relevant stakeholders such as rate payers, councillors, employees, unions, contractors, suppliers, etc. at eTE have an expectation that the equipment and facilities within the organisation will be professionally maintained, reliable and safe. They also expect that there will be controls and checks in place to ensure that the AM system is implemented effectively across the organisation, that performance is measured and that focused improvement initiatives are implemented in order to ensure continuous improvement and increased reliability. The statutory laws and regulations as applicable to AM at eTE are listed in table 5.3.

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Table 5.3: Statutory Laws and Regulations Applicable to AM within eTE [28]

Statutory Requirement	**Reference Documents**
Safety	Occupational Health and Safety Act No 181 of 1993
Environment	Environment Conservation Act No 73 of 1989 National Environmental Management Act No 107 of 1998 as amended and subsequent related Acts
Quality	NRS 048 – National Regulator Standard for Monitoring and Reporting on Power Quality
Industrial Relations	Labour Relations Act 66 of 1995
Accounting/Financial	Municipal Structures Act 117 of 1998 Municipal Systems Act 32 of 2000 Division of Revenue Act (current) Municipal Financial Management Act 56 of 2003 Generally Recognised Accounting Practices (GRAP) National Treasury Local Government Capital AM Guideline
Technical	Electricity Act No 41 of 1987 as amended NRS Guidelines on AM i.e. NRS 093

. PAS 55-2: 2008 defines AM as:

Systematic and coordinated activities and practices though which an organisation optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycle for the purpose of achieving its organisational strategic plan [28]

5.3.2 Aspects of Physical Assets

AM therefore focuses on 4 important aspects of physical assets which are asset provision, asset operation, asset care and external factors. These are each discussed below.

5.3.2.1 Asset Provision

Asset provision revolves around the following:

- the decisions about the replacement or purchase of an asset,
- the analysis of requirements and the specification of the assets to be acquired
- the project management of the acquisition and successful commissioning of the asset, and eventual disposal or replacement thereof.

5.3.2.2 Asset Operation

Asset operation is the use of the asset for its intended purpose, such as production, transport, protection, energy generation, etc. The aim during this phase is to achieve the required output and availability at the optimum operational cost.

5.3.2.3 Asset Care

Asset care (or maintenance) deals with the planning, organising and controlling activities required to keep assets performing to the required standard over its estimated life. Asset Care is thus only a sub-set of the total AM function.

5.3.2.4 External Factors

External factors deal with the unforeseen aspects which could influence the performance of assets such as environmental factors (excessive humidity or dust), abnormally high or low demand, supply chain issues (such as suppliers going bankrupt) or exchange rate fluctuations impacting on the total cost of ownership.

5.3.3 AM KPAs and Goals

5.3.3.1 PAS55 Elements and AM KPAs

Pragma’s 15 AM key performance areas (KPAs) are aligned with the PAS55 elements as illustrated in table 5.4. eTE has adopted these elements as the framework for its AM policy and strategy.

The structure has been arranged into 4 PAS55 elements that align into 15 AM Key Performance Areas (KPAs). The elements include strategy, policy, enablers, controllers, implementation plans, performance assessment and performance improvement.

Table 5.4: AM KPA and PAS55 Element Alignment [29]

PAS 55 Element	**AM KPAs**
AM policy and strategy, with management reviews	1.Strategy management
AM enablers and control	2.Information management
	3.Technical information
	4.Organisation and development
	5.Contractor management
	6.Financial management
	7.Risk management
Implementation of AM plans	8. Asset care plans
	9.Work planning and control
	10.Material Management
	11.Support facilities
	12.Life Cycle management
	13.Project and shutdown management
Performance assessment and improvement	14. Performance measurement
	15. Focused improvement

5.3.3.2 AM Goals

AM will be performed in such a way as to achieve the following long term goals in support of eTE corporate strategy, as summarized and illustrated in figure 5.4 [29].

Increase Revenue

Asset reliability and availability need to be maximized in order impact revenue positively. The city's strategic economic and development plans need to be considered with the ultimate aim of satisfying the customers. Provision should also be made for new equipment that could be implemented as quickly as possible.

Reduce Operating Costs

The factors that drive down operational costs of assets are increased reliability, reduced maintenance, improved performance management and lower acquisition costs. A reduction in the number of faults and breakdowns will also have a positive impact in this regard.

Improve Productivity
Various factors could impact productivity positively, such as reduced maintenance, prolonged asset life, lower downtimes, increased capacity and lower start-up costs.

Reduce Working Capital
The inventory of spares could be reviewed and modified to suit the exact business needs which will effectively drive down the working capital costs.

Reduce Risks
Risks should be mitigated or even totally eliminated, where possible, especially where employee safety and regulatory requirements need to be met. The network should be operated in the safest possible manner.

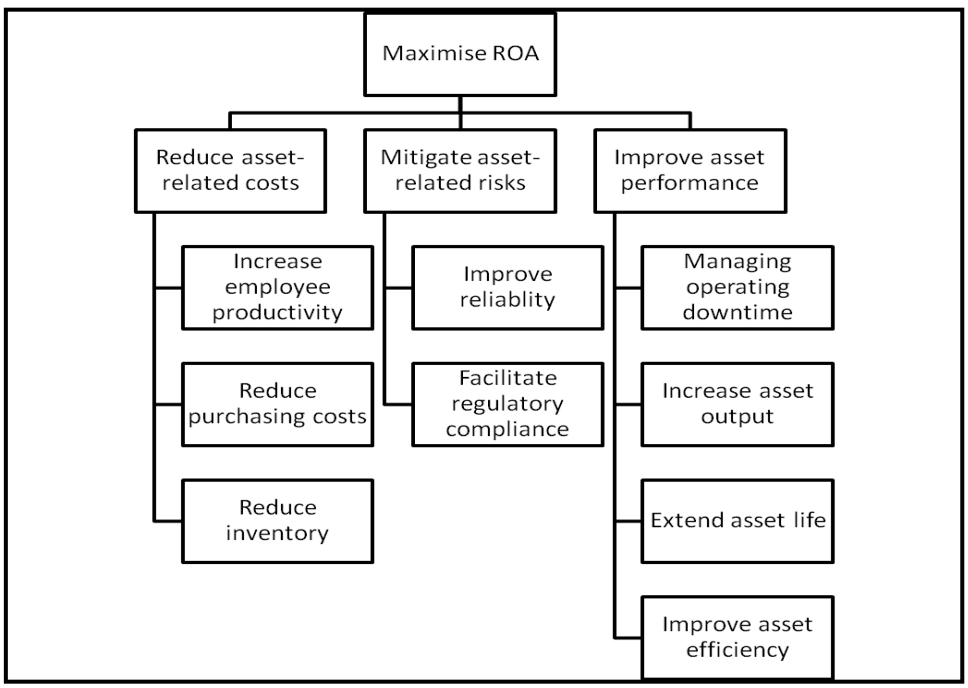

Figure 5.4 eTE AM Goals [28]

5.3.4 Asset Care Plans and Maintenance Strategies

The intention would be to reduce the amount of time spent on non-tactical maintenance, thereby increasing investment in tactical maintenance. The optimum maintenance mix (OMM) for each equipment type will need to be defined and implemented and a layout is illustrated in figure 5.5.

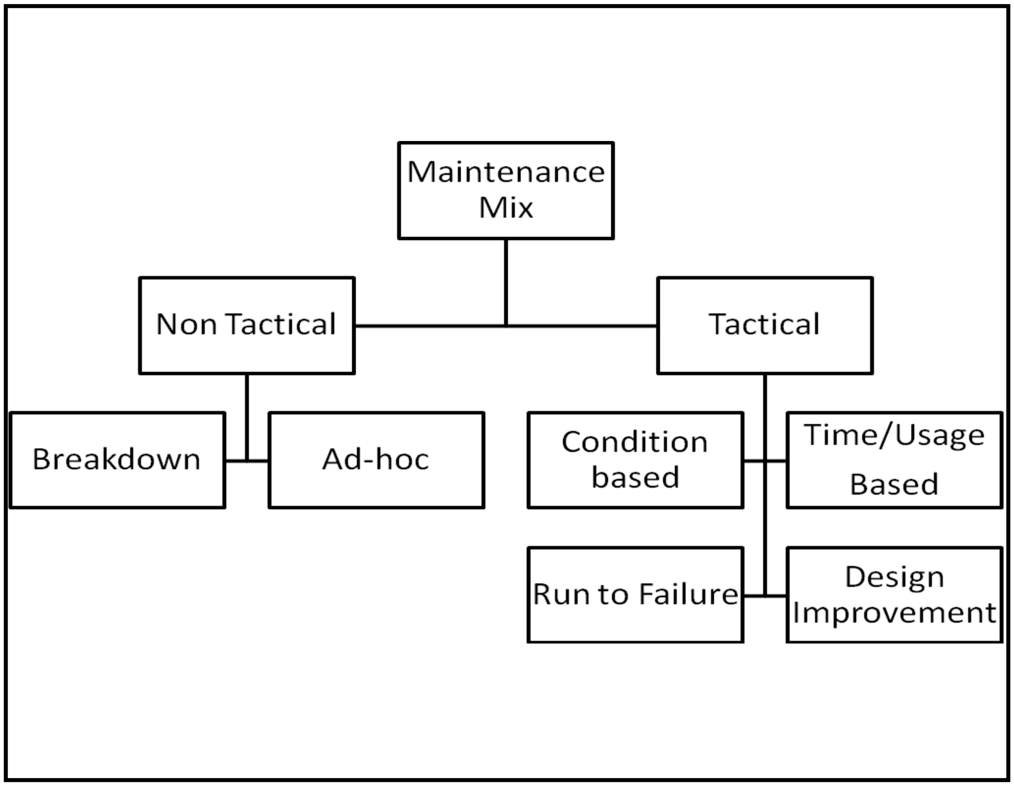

Figure 5.5 AM Maintenance Mix [28]

5.3.4.1 Tactical Maintenance

Tactical maintenance are tasks have been developed through some analytical process, such as Reliability Centred Maintenance (RCM) or Optimum Maintenance Mix (OMM) as an applicable and cost-effective way of improving equipment reliability. These are usually made up of four types of tactical work, which are usage-based maintenance, condition-based maintenance, run-to-failure and design improvement maintenance.

5.3.4.2 Non-Tactical Maintenance

Non-tactical maintenance is usually reactive work and not the result of any asset care plans, based on an analysis like OMM or RCM. It covers activities associated with unexpected equipment failure and potential failures.

5.3.4.3 Reliability Centred Maintenance (RCM)

The concept of RCM is based on assessing the various maintenance options and determining the optimum strategy on assets so that it fulfils its operational requirements. This could be a single tactic or a combination of various tactics to achieve the most desirable strategy.

5.3.4.4 Optimum Maintenance Mix (OMM)

The OMM methodology is based on RCM and aims to simplify the RM process by starting with criticality analysis that identifies focus areas. OMM combines some RCM steps to simplify the development of Asset Care Plans (ACP).

5.3.4.5 Condition Based Maintenance (CBM)

Condition Based Maintenance (CBM) covers all inspections and tests (condition monitoring) which are done to verify the condition of equipment in order to predict and prevent failures before they occur.

5.3.4.6 Design Improvement

Design Improvement covers all modifications and projects are made to equipment to remove a cause of failure.

5.3.4.7 Run to Failure (RTF)

The concept of Run to Failure (RTF) is a maintenance tactic that allows items to fail because prevention of that failure is sometimes impossible or very often not cost effective.

5.3.4.8 Usage Based Maintenance (UBM)

UBM is maintenance conducted at regular, scheduled intervals of usage (kilometres, running hours, months, etc), which were established to avoid failure. It can include inspections, services or replacements. It is only effective if there is a certain age-related deterioration (wear- out).

Asset care plans will be reviewed and refined on an ongoing basis to improve asset performance and reduce maintenance costs, as illustrated in figure 5.6.

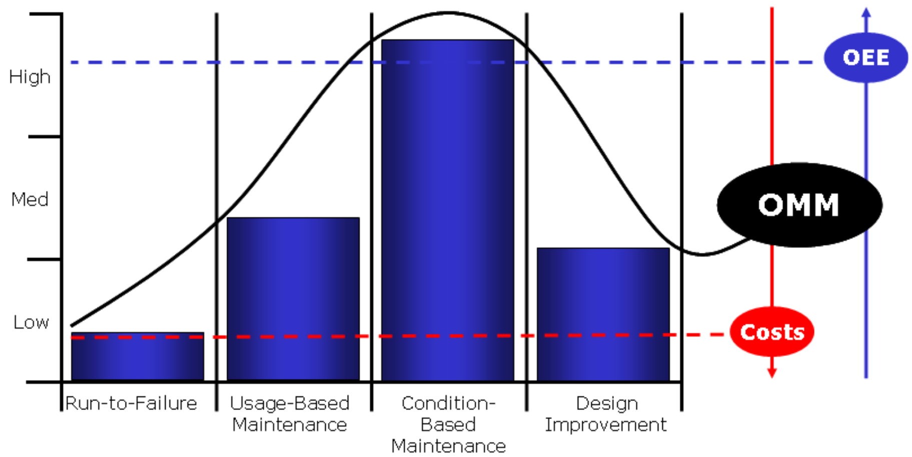

Figure 5.6 Asset Care Plan Layout [28]

5.4 Summary of Chapter

eTE has implemented various smart systems across its electrical network that further contributes to the impact of SG systems. Street lighting, albeit a small portion of the electrical network, is sometimes referred to as the “shop window” of the municipality as this somehow tends to create an impression on tourists. The organization has been very proactive in the research and implementation of new lighting technologies. The LED projects and the implementation of a lighting telemanagement system stand out as major contributors in this area. The organization has also taken a decision to rollout a major SM project that will in the future, indicate more tangible evidence of the impact of SG systems, especially from a consumer enablement perspective. eTE has also invested a lot of funds into its AM drive into order to comply with legal and statutory requirement and ultimately to overcome the major challenges facing the municipality

Chapter 6

PERFORMANCE ANALYSIS OF ETE SMART SYSTEMS

6.1 Technical Performance Indices

6.1.1 Requirements for System Performance Indices

Indices that provide accurate and unambiguous information on system technical performance are important tools in the management of electrical network performance [30]. These indices could provide the foundation for dialogue between major stakeholders, especially the National Energy Regulator of South Africa (NERSA), its license holders, all levels of government, and the various customer groups.

eThekwini abides strictly to the requirements of NERSA in terms of reporting and the measuring of the various indices could also be used as an indicator in terms of the effectiveness of SG implementation initiatives. In this chapter, the various indices of eThekwini shall be discussed from 2011 up until 2014 and annual data shall be compared for an indication of the trends in specific areas. This would be more meaningful as opposed to comparisons with other organizations, as the localized comparisons will give us an indication of the SG maturity within eTE and the impact thereof.

The discussion in the sections to follow pertains to the various performance indices of the eThekwini network from 2011 to 2014. Reports are generated on a monthly basis which contains information that goes back for a period of 12 months so all July reports were used to maintain consistency. The readings used are the monthly average over a period of 12 months for the year in review. The number of connection at the beginning of the cycle is used as a reference, especially in cases where the number of connection points change during a 12-month period. Connection point interruptions that arise during a major event are not included in the calculation of the index. Connection point interruptions that arise during a major event are not included in the calculation of the index. Momentary events are not meaningful as the index will improve for more momentary events.

6.1.2 Categories of Reporting

NRS 048, together with NRS 048-6, defines two categories of indices for reporting: [30]
a) connection point interruption indices
b) end-customer interruption indices.

6.1.2.1 Connection point interruption indices

This set of indices is usually recommended where there is a need to report on the overall performance of the HV network, independently of the actual impact on end-customers. The term “connection point” is used to denote both load and generation points. The connection point method provides most appropriate for transmission license holders as it permits the key aspects of transmission-related interruption duration, frequency and severity to be reported independently of distribution network performance.

6.1.2.2 End-customer interruption indices

This set of indices describes the impact of the interruption performance of the HV network in terms of its actual impact on the interruption performance of end customers. The interruption frequency and duration indices used are based on the number of end customers affected by interruption that originates in the HV system.

6.1.3. System Performance Indicators

6.1.3.1 Frequency of sustained connection point interruptions:

The system average interruption frequency index (SAIFI) for sustained connection point interruptions (CPI) are given by: [30]

$$\text{SAIFI-CPI} = \frac{\Sigma\ (\text{number of sustained connection point interruptions})}{\text{Total number of connection points}} \tag{6.1}$$

SAIFI statistics as illustrated in figure 6.1, indicate a decrease in this performance indicator from 2011 until 2014, however there was a huge peak in 2013, indicating the largest number of sustained connection point interruptions.

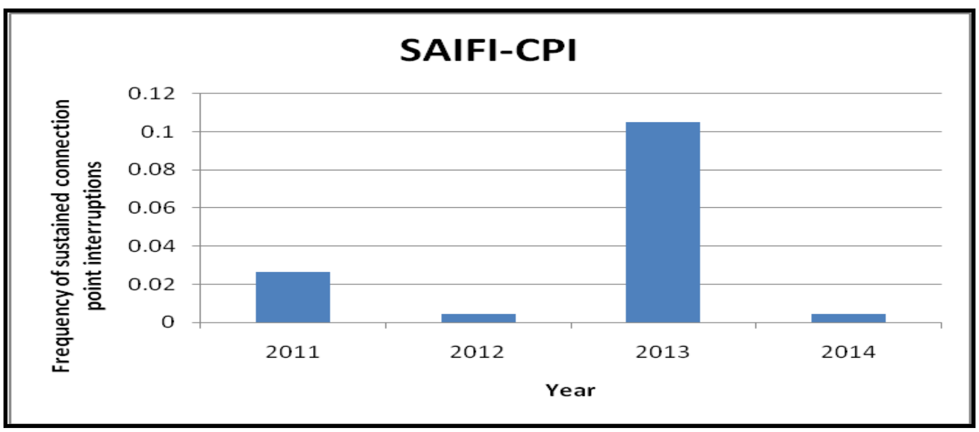

Figure 6.1: Historical eTE SAIFI Statistics [31]

6.1.3.2 Cumulative duration of sustained connection point interruptions:

The system average (aggregated) interruption duration index per connection point for sustained connection point interruptions is given by: [30]

$$\text{SAIDI-CPI} = \frac{\Sigma \text{ (duration of the sustained connection point interruptions)}}{\text{Total number of connection points}} \quad \text{(min)} \qquad (6.2)$$

SAIDI as illustrated in figure 11.2, shows a decrease from 2011 to 2014. This indicates a drop in the amount and duration of interruptions; however the peak occurred in 2011, even though the SAIFI figure was lower in 2011 compared to 2013. This indicates that eTE is developing the ability to deal with a larger number of interruptions in a shorter space of time.

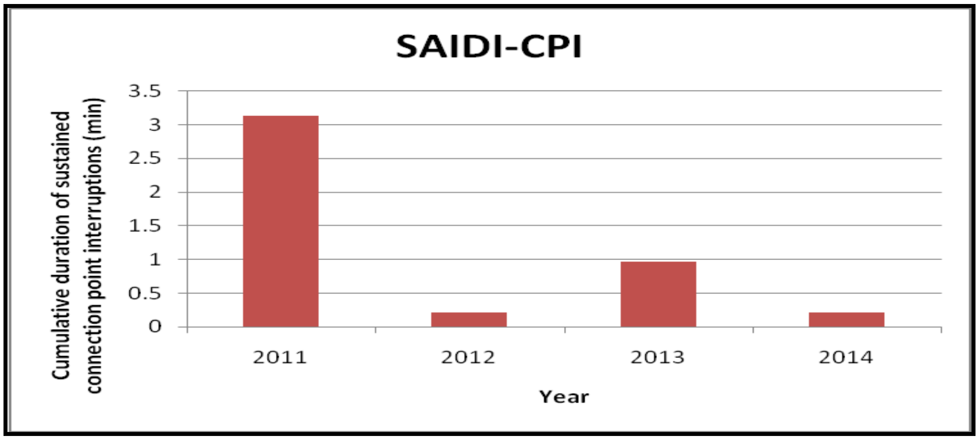

Figure 6.2: Historical eTE SAIDI Statistics [31]

6.1.3.3 Restoration time of a sustained connection point interruption:

The system average interruption restoration time index per connection point for sustained connection point interruptions are given by: [30]

$$\text{SAIRI-CPI} = \frac{\Sigma \text{ (restoration times of individual sustained connection points)}}{\Sigma \text{ (sustained connection point interruptions)}} \quad \text{(min)} \; (6.3)$$

SAIRI statistics as illustrated in figure 11.3, indicate that restoration times of outages have come down significantly from 2011 to 2014. As discussed in the section above, this once again demonstrates the organization's ability to handle a larger number of interruptions in a shorter space of time.

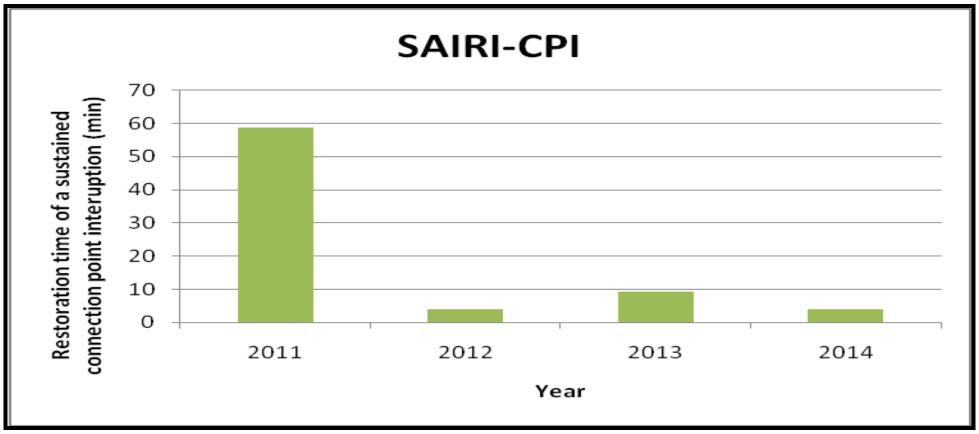

Figure 6.3: Historical eTE SAIRI Statistics [31]

6.1.3.4 Number of sustained interruption events

The number of sustained interruption events (NOI) is given by: [30]

NOI = Sum of sustained interruption events (6.4)

Each event is associated with:

- A sustained interruption to one or more connection points due to a common cause
- The inability to supply energy for more than 1 min

The sum is calculated over a 12-month period. All events (including major events) shall be included in the reported index. Planned and unplanned events may be reported separately. The statistics as illustrated in figure 11.4 indicate a decrease from 2011 to 2014.

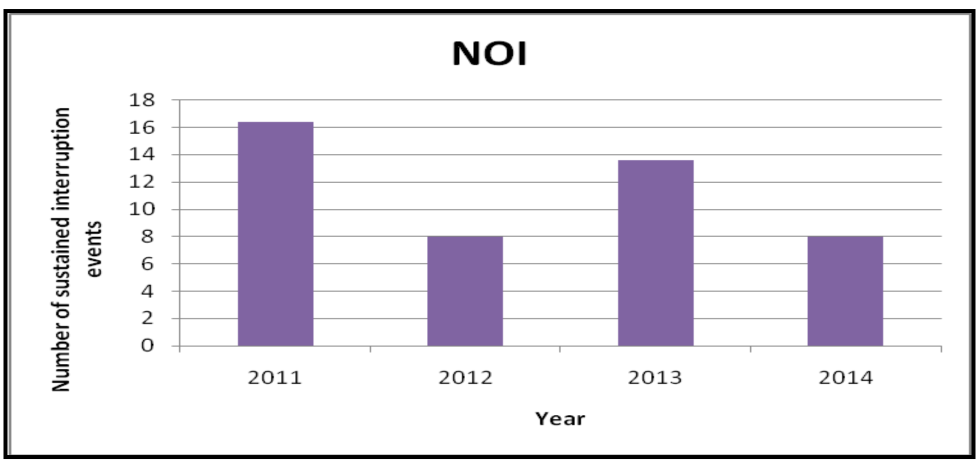

Figure 6.4: Number of Sustained Interruptions [31]

6.1.3.5 Number of involuntary customer reduction in load events

The number of involuntary customer reduction in load events (NOLR) is given by: [30]

NOLR = Sum of involuntary customer reduction in load events (6.5)

Each involuntary customer reduction in load event is associated with:

- An involuntary load reduction (without an associated sustained connection point interruption)
- The inability to supply the full energy for more than 1 min.

Load reduction events initiated by generation factors, such as demand-side programs and interruptible load agreements are not included in the calculation. Under-frequency load shedding events are also not included in the calculation. These events shall be reported separately for each event and the sum is calculated over a 12-month period. All events (including major events) shall be included in the reported index. The statistics for the past 4 years is illustrated in figure 11.5.

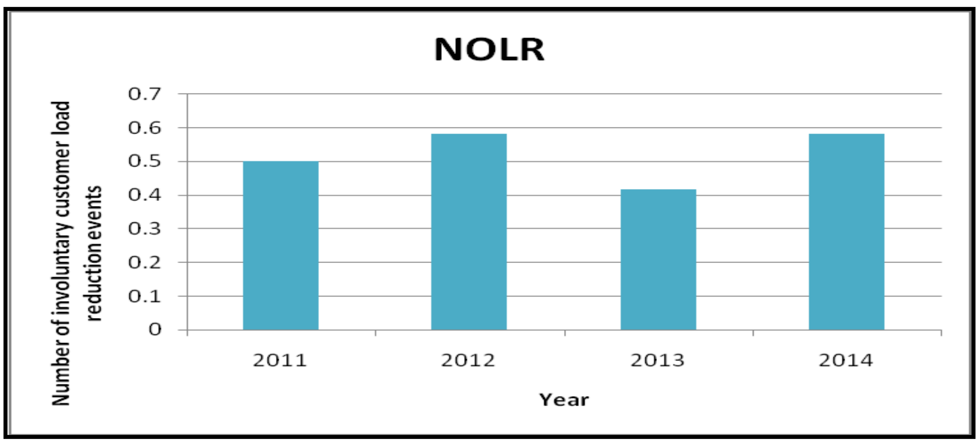

Figure 6.5: Number of Involuntary Customer Load Reductions [31]

6.1.3.6 System event severity indices

The severity of an interruption event or an involuntary customer load reduction event is quantified by the associated energy-not-supplied, in MWh (in the case of end-use customers

6.2.1 System minutes (SMn)

6.2.1.1 In the case of loads, the severity of an individual interruption event is given as: [30]

$$\text{SMn (supplied)} = \frac{\text{Estimated energy not supplied (MWh)} \times 60}{\text{System annual maximum demand (MW)}} \text{ (min)} \qquad (6.6)$$

The system annual maximum demand shall be that for the previous reporting year. The previous year's value is used for practical purposes so as to ensure that the system minutes associated with a particular incident in the early part of the year does not have to be changed if a new system peak is reached. This would result in a higher system minute value for the reporting year in the case where the system peak increases from one year to another.

The statistics as illustrated in figure 11.6, indicate a drop from 2011 to 2014 in system minutes measured for energy not supplied. This is positive and probably the biggest indicator in demonstrating that the implementation of SG is having a positive impact on the management of the electrical network. The peak in 2013 is due to the large number of interruptions that occurred in that year.

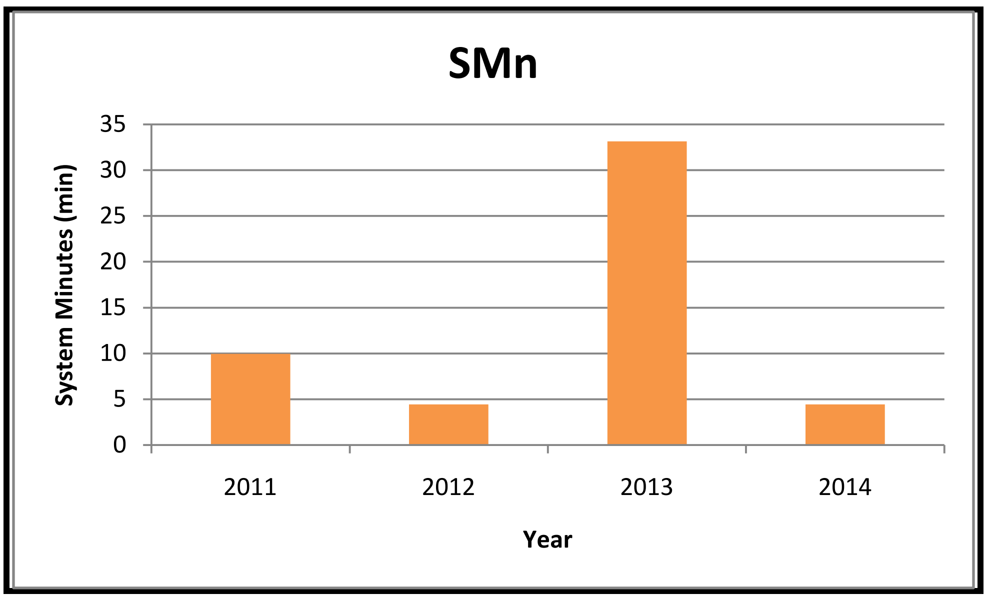

Figure 6.6: Overall System Minutes [31]

Figure 6.7 illustrates the SM lost, but only due to factors within eTE's control [31]. Third party issues refer to incidents beyond eTE's control such as power swings on the Eskom network, cable damage due to excavations from 3rd parties, etc. This indicator shows a drop from 2011 to 2014, with the usual peak in 2013. There, is still however significant room for improvement in this area.

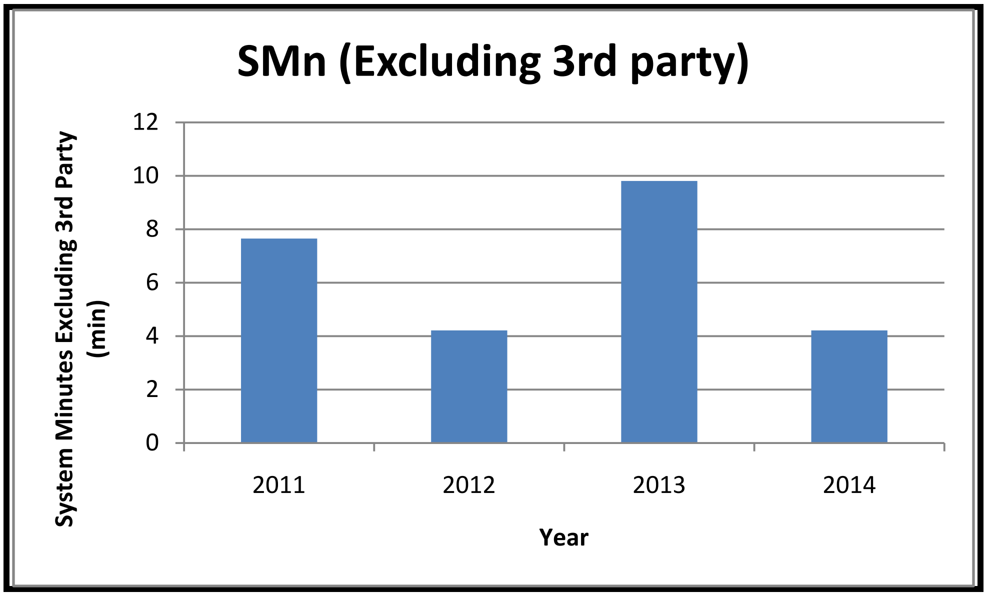

Figure 6.7: System Minutes (Excluding 3rd Party) [31]

6.1.3.7 System interrupted energy factor

The severity of an individual interruption event is given as the ratio of annual MWh not supplied to the annual terawatt hours (TWh) supplied. In the case of end-use customer connections, this is defined as follows: [30]

$$SEF = \frac{\text{Estimated annual energy not supplied (MWh)}}{\text{System total annual energy supplied (TWh)}} \qquad (6.7)$$

This performance indicator as illustrated in figure 6.8, shows a decrease from 2011 to 2014 with the usual peak in 2013 due to the larger number of sustained connection point interruptions.

Each major event is reported individually and described by giving the following:

- Location of the event
- Cause of the event
- Degree of severity of the event and the aggregated system minutes
- Number of connection point interruptions during the event
- Duration of the event.

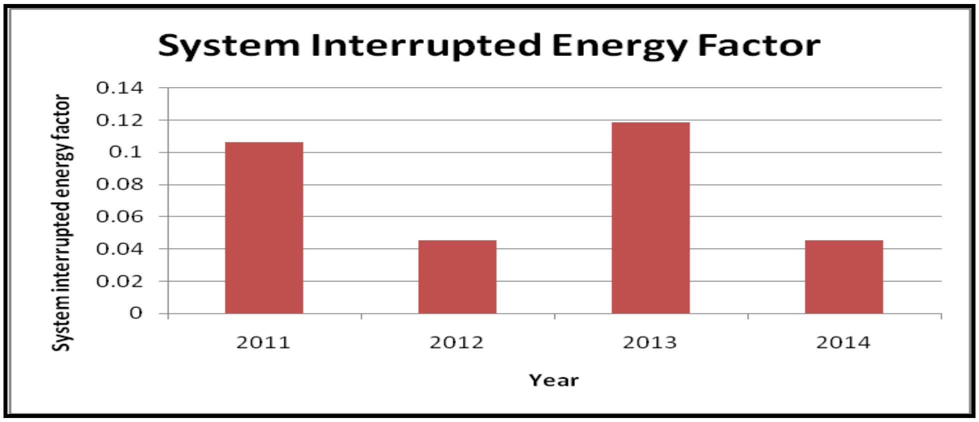

Figure 6.8: System Interrupted Energy Factor [31]

6.1.3.8 Interruption severity: High-voltage supply loss index (HVSLI)

The severity of an interruption event can be approximated by the transformer capacity impacted. The HV supply loss index is calculated over a 12-month moving period as: [30]

$$HVSLI = \frac{\Sigma \text{ (HV transformer capacity lost (MVA)} \times \text{duration (minutes))}}{\text{Total installed HV transformer capacity on the network (MVA) (min)}} \quad (6.8)$$

The HVSLI performance indicator as illustrated in figure 6.9, shows a decrease from 2011 to 2014, with the usual peak in 2013 due the higher amount of sustained connection point interruptions. This once again indicates that the implementation of SG systems is having a positive impact on the management of the electrical network.

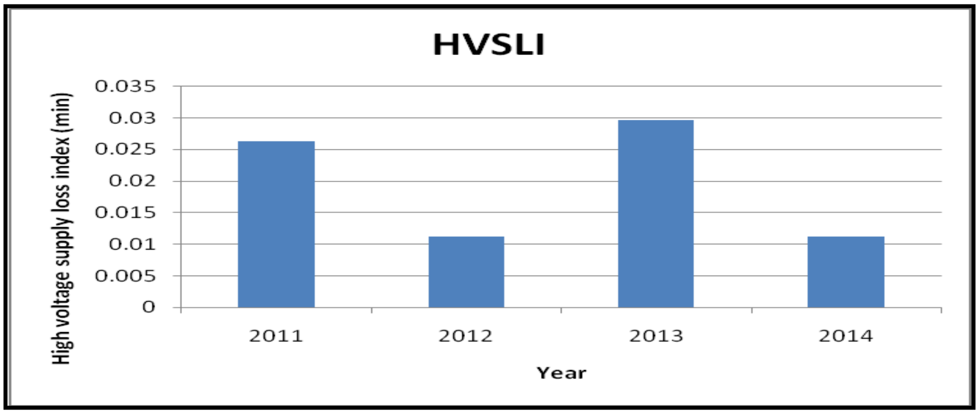

Figure 6.9: HV Supply Loss Index [31]

6.2 eTE Statistical Data Analysis

Analysis of the statistical data that characterizes the overall business performance of eTE may give us an indication of the impact of SG systems on the electrical network. As discussed earlier in this study, some of the main objectives of SG are to drive down the operational costs, minimize the price of electricity to customers and reduce the overall environmental impact. The graphs and information discussed in the sections to follow go back for up to periods of twelve financial years to give us a clearer indication on the status of the business and the potential impacts of SG systems.

6.2.1 Energy Purchased and Energy Sold

The energy sales as indicated in figure 6.10, has risen from around 9000 GWh in 2001 to approximately 11000 GWh during the past financial year. This amounts to a 22% increase over twelve years, whereas the customer base has increased by 18.5% during the same period. There is a close co-relation between the energy purchased and energy sold which indicates that the overall losses have been fairly constant. The total losses at eTE have been fluctuating between 5 and 6.22% over the past 12 financial years. The figure is calculated by taking the difference between the energy purchased and sold.

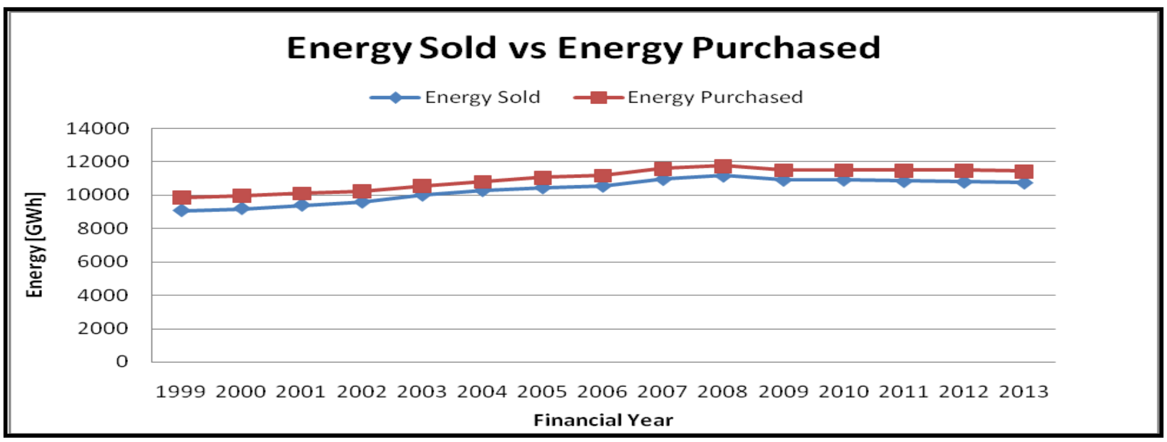

Figure 6.10: Energy Sold versus Energy Purchased [10]

6.2.2 System Maximum Demand

The system maximum demand as illustrated in figure 6.11, had increased from 1600 MVA in 2001 to around 1800MVA in 2004 and has been steadily consistent around this figure until the last financial year. All of the maximum demands were experienced during the high demand (May, June and July) winter months where the demand for electricity is higher due the colder weather conditions which encourages the use of heating devices, air conditioners and is also a period where water heating is at its maximum. The growth constantly fluctuates between the positive and negative sides of the scale.

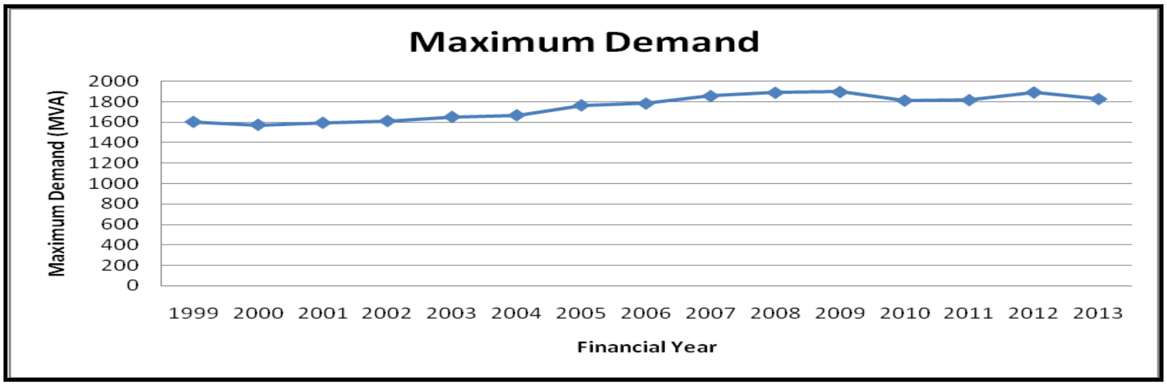

Figure 6.11: System Maximum Demand [10]

6.2.3 Number of Customers and Employees

The customer base as illustrated in figure 6.12, has steadily increased from just on 600 000 in 2001 to around 711 000 currently. It currently consists of approximately 48% prepayment, 45% credit metered residential, 6.3% business and 0.7% bulk and other customers. There are 7 bulk customers who are the key customers to the business and were termed “contestable customers” during the recent Electricity Distribution Industry (EDI) restructuring process in that they consumed more than 100 GWh annually.

The number of employees at eTE has risen from around 1800 in 2001 to approximately 2200 in 2010 and has been fairly consistent around this mark for the past 4 years. eTE experienced huge turnover of staff, especially during the 2006/2007 financial years where the organization experienced a minimum staff level of around 1600. This was during the period where a lot of experienced staff were either retiring or emigrating due to various reasons. eTE had embarked on an aggressive recruitment drive to attract suitable technical staff at Electrician, Technician, Technologist and Engineer levels into the organization. Although this has been fairly successful, it is being found the organization needs to consider restructuring to cater for the changing business conditions.

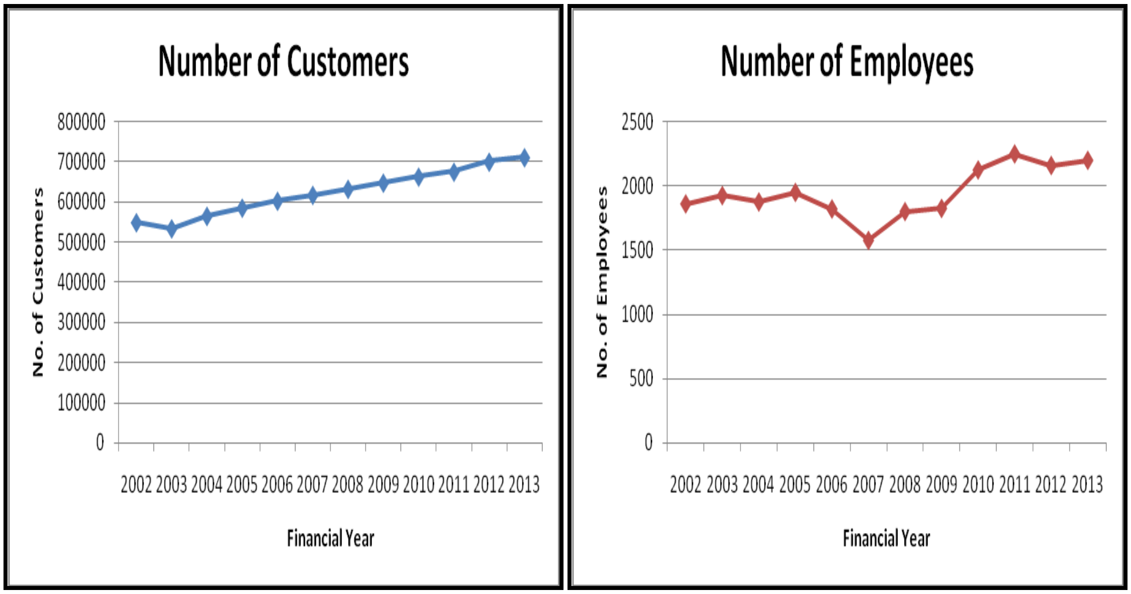

Figure 6.12: Number of Customers and Employees [10]

6.2.4 Capital and Operating Expenditure

The capital and operating expenditure for the past 7 financial years is depicted in figure 6.13. The capital expenditure was R419m in 2007 and has risen to R526m in 2013, with a peak of R683m in 2009. These figures indicate that eTE have been progressive in this regard as the expenditure was relatively close when compared to the initial estimates and forecasts. The operating expenditure on the other hand has been on a constant uptrend and has increased from R1.03bn in 2007 to R2.27bn in 2013 which equates to a 220% increase in just a period of 7 financial years. The operating costs used for this exercise excludes the cost for the purchase of electricity from Eskom which accounts for approximately 60% of the total eTE expenditure per annum. The main contributing factors to the rapid rise in operating costs is the high number of faults on an ageing network, large volumes of third party cable damage, unacceptable levels of infrastructure theft and vandalism and general inflation rates across this sector.

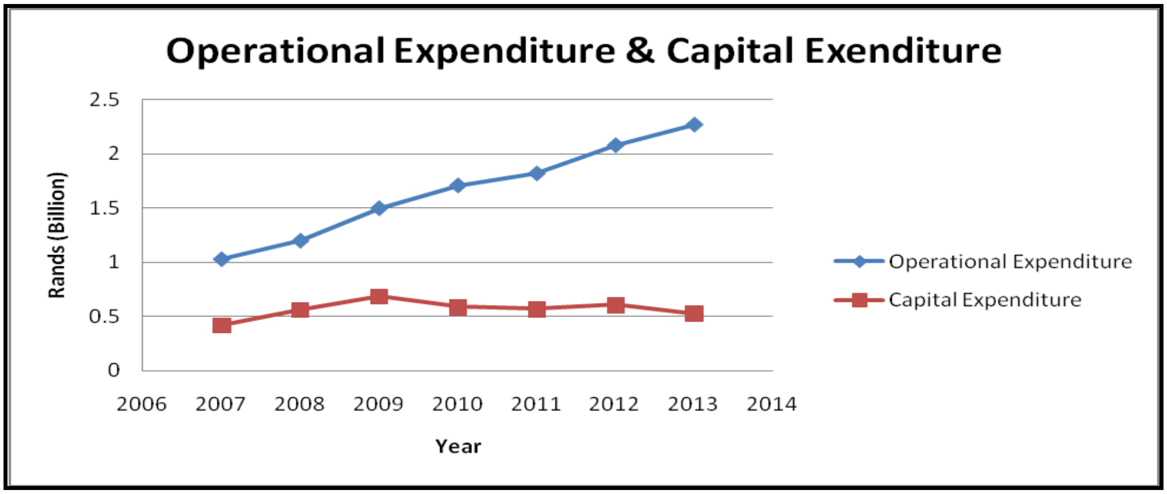

Figure 6.13: Capital and Operating Expenditure [10]

6.2.5 Electricity Tariffs

Figure 6.14 depicts the historical electricity tariff rates at eTE for the residential, commercial and industrial sectors. It can be seen that the tariffs have been on a steady rise from 2008 to now, with the residential tariff rising by 226%, the commercial tariff by 249% and the industrial tariff by 266% during the past 7 financial years. eThekwini tariffs are designed to be as cost reflective as possible whilst maintaining business sustainability. The main factor however is the Eskom tariff increase which is implemented annually and this has a direct impact on the eThekwini tariffs, with eTE being a pure distributor of electricity.

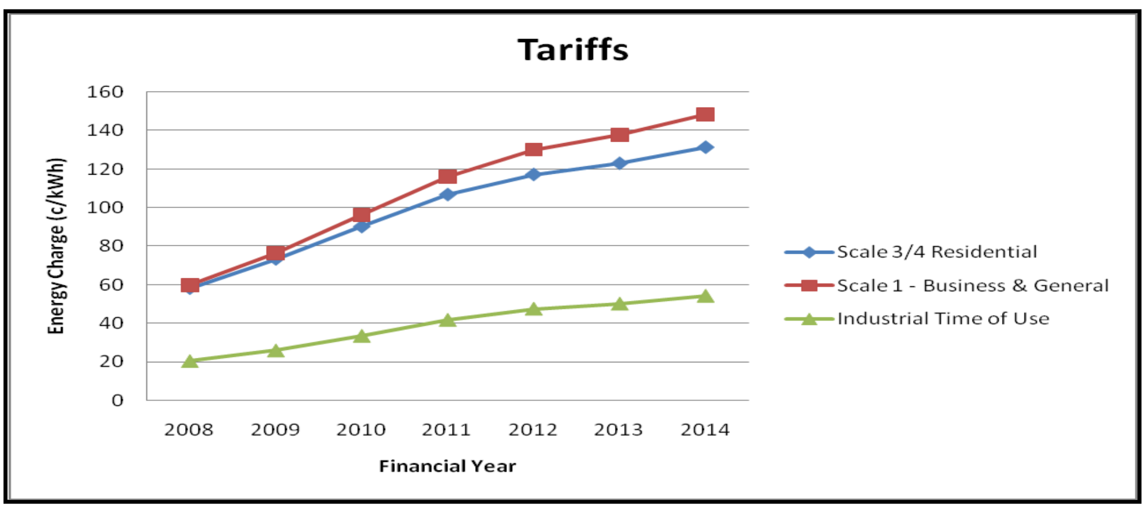

Figure 6.14: Historical Tariff Rates [10]

6.2.6 System Losses

The total losses at eTE as illustrated in figure 12.6, has been fluctuating between 5 and 6.22% over the past 12 financial years. The figure is calculated by taking the difference between the energy purchased and sold. This value would therefore include the technical as well as the non-technical losses. A total energy loss of 667 412 169 kWh was experienced during the past financial year. The resultant revenue impact was R396 million which was a 9% increase from the previous financial year.

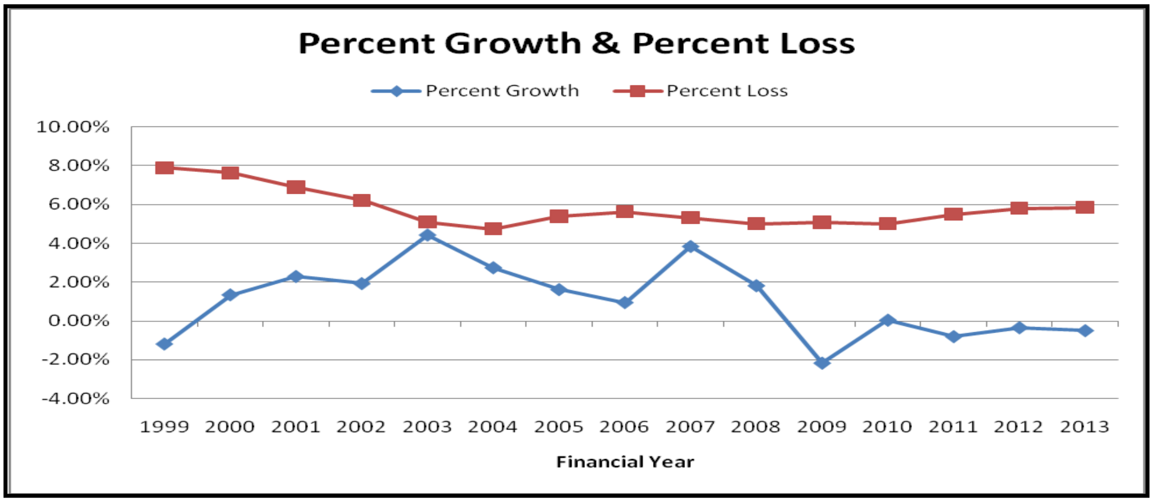

Figure 6.15: System Losses and Sales Growth [10]

During the past financial year, the total losses amounted to 5.85%. A measurement was done on the HV model and it was found that the system experienced 6.4 MW losses at the time of the system peak, but this relates only to technical losses on the 275 kV and 132 kV network including 275/132 kV, 132/11 kV and 132/33 kV transformers. The 33 kV network including 33/11 kV transformer losses and the 11 kV and below network losses are excluded. Considering the monthly System Maximum Demands (SMDs) from September 2013 to August 2014, the SMD for these 12 months occurred on the 19th of February 2014 at 3:30 PM. The SMD measured was 1667.41 MW. The MW and MVAr losses were 6.4 and 225.1 respectively. The Eskom 2014 PSSE case file at the time of the Eskom system peak from the 2013 Annual Transfer Limit Study was used together with the eTE 2014 case file to be used in the 2014 study. The study is usually carried out in November/December each year. The EE model contains the 275 and 132 kV network down to 11 kV bus bars at HV Substations. The 33/11 kV substations are not included in the PSSE model but are included in the DigSilent model which is currently being updated. The 33/11 kV substations are being planned for phase out.

6.2.6.1 Measures to Mitigate System Losses

The following measures have been put in place in order to mitigate losses: [10]

Configuration and Design of Network
The optimum designs are proposed by the Design and Planning Engineers that considers correct ratings and ideal configuration in order to minimize system losses.

Network Management
The network is managed in a manner that enhances reliability and promotes efficiency. The various maintenance schedules have also been revised to achieve this.

Optimum Loading of Network
Various factors are considered in adopting the most efficient electrical network loading configuration to minimize risk and ensure quality of supply. It has been found that illegal connections contribute significantly to the system losses.

6.2.6.2 Initiatives to Curb Illegal Connections

The following initiatives have been implemented in an effort to curb illegal connections: [10]

Inspections, Audits and Sweeps
The Revenue Protection Branch at eTE is dedicated to the function of carrying out inspections, audits and sweeps across the supply. Their responsibility is also to remove illegal connections and to carry out investigations in theft prevalent areas.

Security and Intelligence Teams
In many instances, eTE makes use of private investigators and security companies to apprehend suspects and with the gathering of information.

Theft Deterrents at Substations
Substations are equipped with various theft deterrents, such as pepper gas spray systems, electronic access control, security guards and CCTV cameras in some instances.

Hotline to Report Theft
The reporting of illegal connections and any acts of theft can be reported via a 24 hour hotline.

6.2.6.3 Method for Calculating Losses

The method of calculating losses is as follows: [32]

Energy loss is given by:

$$E_{Loss} = E_{Delivered} - E_{Sold} \quad (6.9)$$
$$C_{Loss} = U_{Cost} \times E_{Loss} + M_{Cost} \quad (6.10)$$
$$C_{NTL} = C_{Loss} - C_{TLoss} \quad (6.11)$$
$$C_{NTL} = U_{Cost} \times E_{Loss} + M_{Cost} - C_{TLoss} \quad (6.12)$$

where,

Loss C = Revenue loss due to technical/additional losses
Cost U = Unit cost of electricity
Cost M = Maintenance and additional operation costs.
NTL C = Non-technical loss cost component
TLoss C = Technical loss cost component.

Substantial losses are incurred in the processing, delivery and utilization of electricity. These losses are both technical and non-technical, but need to be minimized to optimize returns on investment [32]. Non-technical losses (NTL) can be attributed to and include the following: [32]

- Non-payment of electricity bills
- Unauthorized line tapping and diversion
- Losses due to faulty meters and equipment
- Inadequate or faulty metering
- Poor revenue collection techniques
- Inaccurate meter reading
- Incorrect billing
- Loss or damage to equipment
- Incorrect estimation of unmetered supplies
- Inefficiency of business and technology management systems

The types of non-technical losses listed above are prevalent in the lower voltage levels of the network, which ultimately results in a loss of revenue. The cost of these losses is often factored into tariff calculations as an input cost and effectively passed onto the customers resulting in higher electricity costs.

6.3 AM Reports and Statistics

Below are some statistics that have been produced from the various AM systems. There is clearly more visibility into the system and a clear indicator in terms work orders created, tactical work completed, schedule attainment and backlogs. The intention is to carry out as much tactical work as possible but the high volumes of breakdowns and non-tactical work due to theft, vandalism, illegal connections and various other factors, result in the desired amount of tactical work not being timeously completed.

6.3.1 HV Backlog Work Orders

The graph in figure 6.16 illustrates a trend of backlog work orders from the HV Cables, Lines and Substations Branches. There is a clear problem with the HV Substation Branch where the backlog has been consistently over 2000 for the past financial year. The HV Cables and Lines Branches indicate a consistent backlog of just over 500 for the past financial year. Backlog is defined as work issued, but not yet completed, so this work may not necessarily be overdue but just incomplete at the time of producing the statistics.

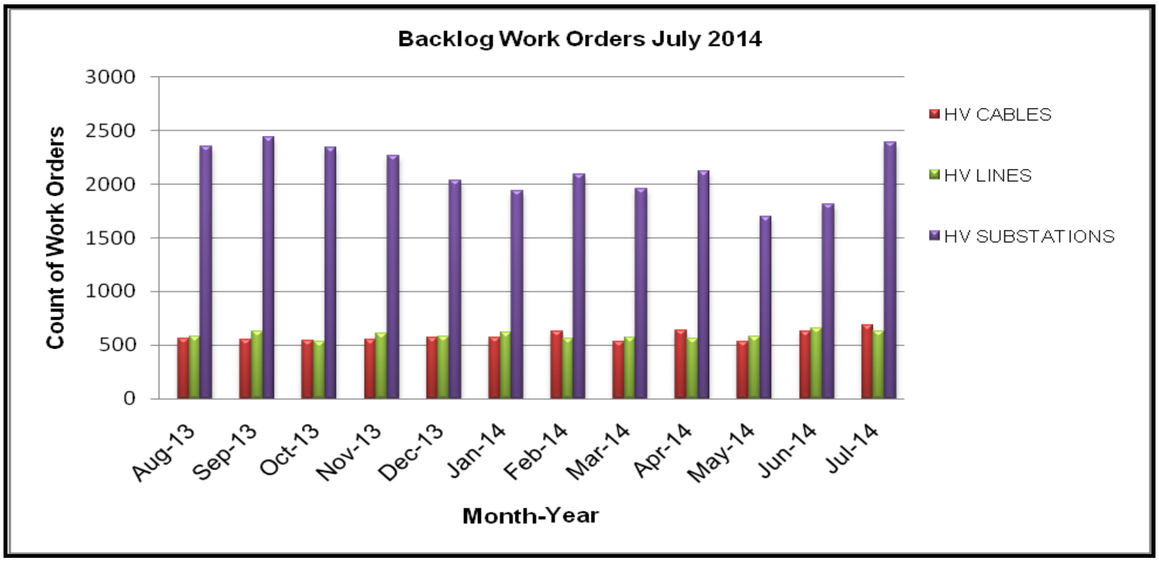

Figure 6.16: HV Backlog Work Orders [35]

6.3.2 Tactical Work Order Trend

Figure 6.17 is an illustration of the tactical work order trends, but this is however avergaed across the 6 MV/LV depots. It can be seen that the target is set at 60% but this has not been achieved during the past financial year. The poor tactical work completion statistic is once again a reflection of the high volumes of non-tactical work that creeps into the system due to various reasons and factors.

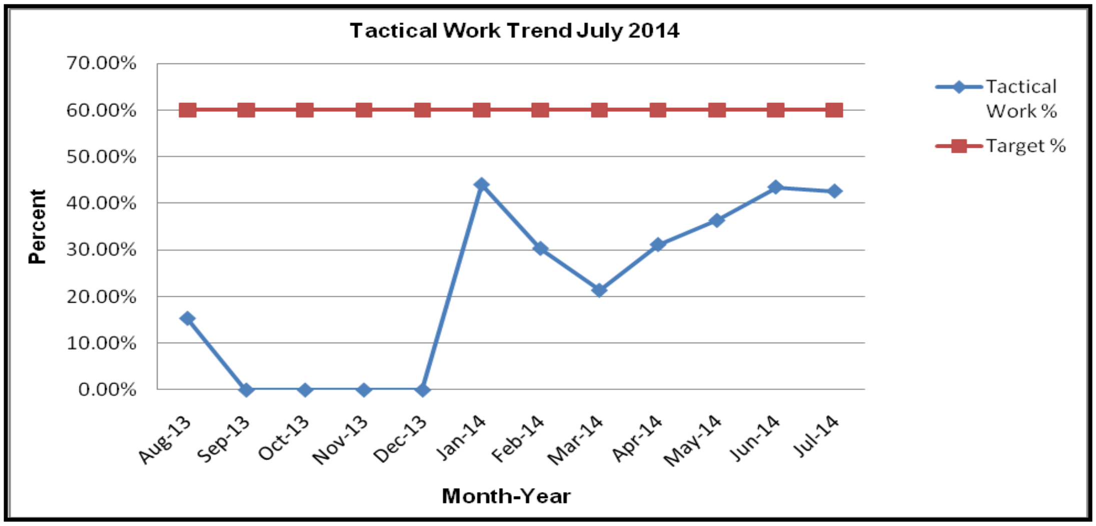

Figure 6.17: Tactical Work Order Trend [35]

6.3.3 MV/LV Schedule Attainment

Figure 6.18 is an illustration of the overall schedule attainment at the 6 MV/LV depots across the organisation. The attainment is fairly consistent and close to the target of 60%. The target of 60% has been set as a realistic figure, considering what is achievable with the current organisational structure, staff compliment and the state of the network.

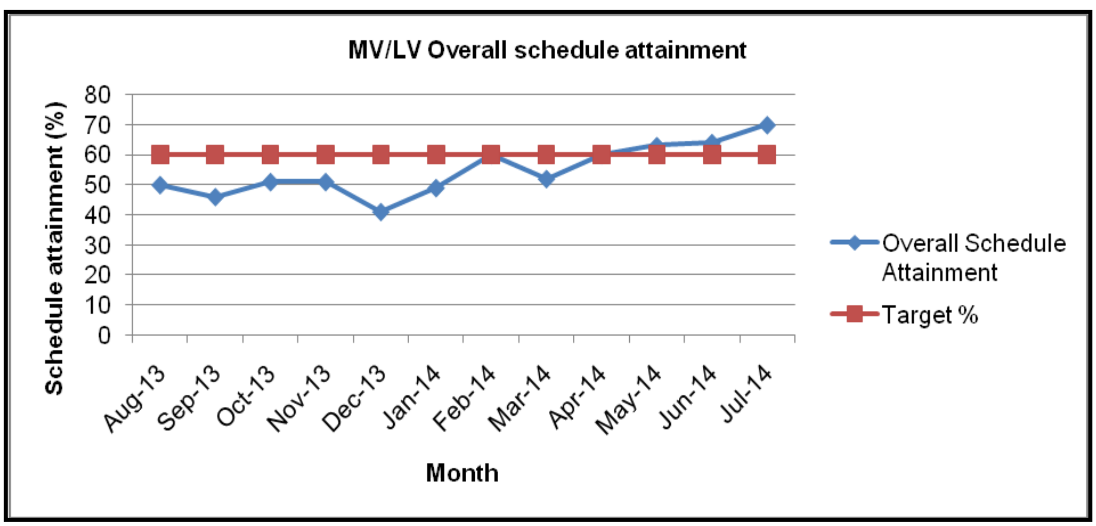

Figure 6.18: MV/LV Schedule Attainment [35]

6.3.4 MV/LV Backlog Work Orders

Figure 6.19 is an illustration of the backlog work orders across the 6 MV/LV depots. This is clearly a consistent problem where the backlog had peaked at close to 70 000 in December 2013. These were analysed and it was discovered that the large numbers are owing to various duplicate work orders placed in the system for the same work and work orders not being closed off when the work has in fact been completed. An exercise has been put in place and measures are being implemented to address these challenges.

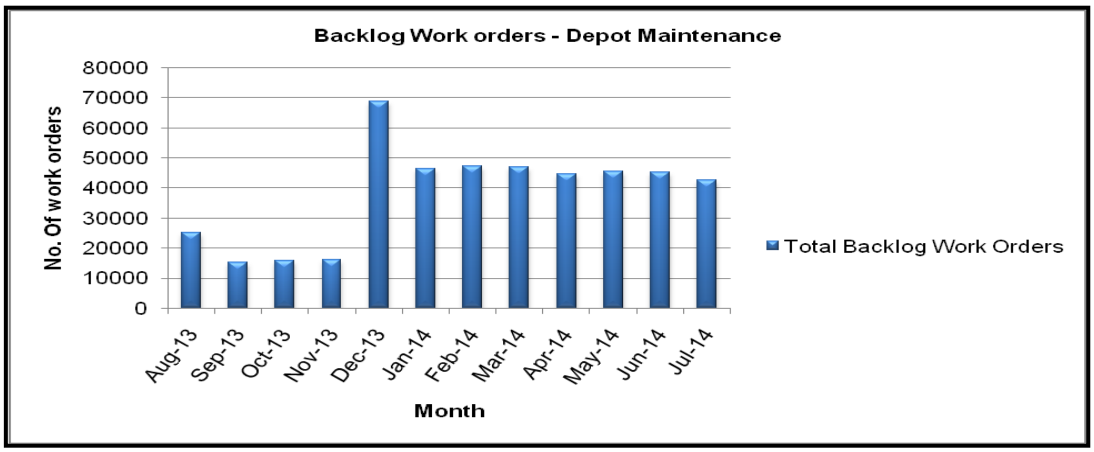

Figure 6.19: MV/LV Backlog Work Orders [35]

6.3.5 Work Order Age Analysis

Figure 6.20 is an illustration of the work order age analysis across the 6 MV/LV depots. This area is of major concern as many work orders are way past the stiplutated age category limits. Similar to the initiative mentioned in the previous section, measures are being put in place to address this challenge.

The current priority categories are:

- Immediate Hazardous
- 7 Day Hazardous
- 60 Day Priority
- 90 Day Priority
- 120 Day Priority

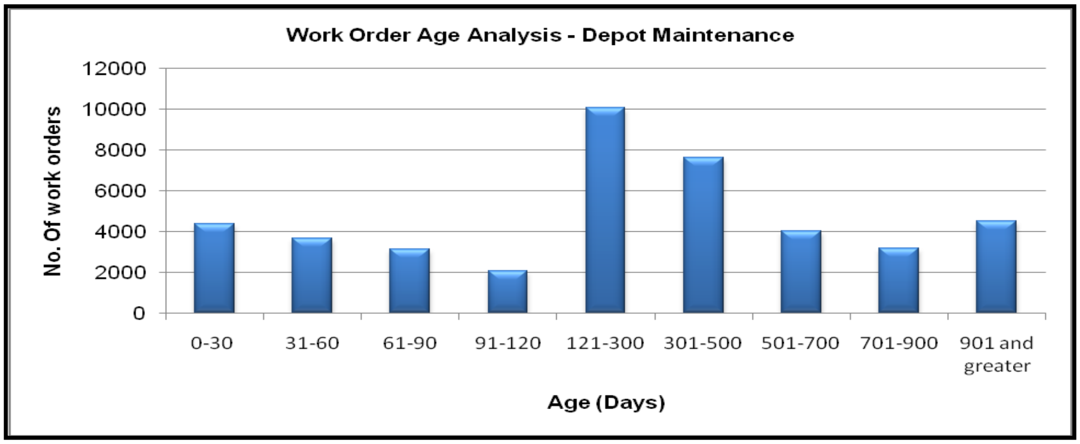

Figure 6.20: Work Order Age Analysis [35]

6.4 Summary of Chapter

eTE has various SG initiatives across its electrical network and the impact of these systems can either be evaluated on an individual or overall basis. The overall analysis gives us a holistic view and the impact on the entire system, however with this approach many other variables that have an impact on the system also need to be considered. eTE reports very accurately to NERSA on its operations so most of the system performance indicators are readily available. The analysis indicates that the implementation of SG systems is yielding positive results in various areas of system performance. Historical statistical data indicates that the eTE electrical network and customer base is always growing and the business dynamics has to cater for this growth, with the aid of SG systems. It has also emerged that the organizational structure and business needs are not balanced in some areas and these need to be urgently looked at. The various monthly AM reports provide extremely useful information and give the organization a much clearer picture of its electrical network and operations. A big positive for eTE is that it has always been a financially viable business whilst maintaining very competitive electricity tariffs, which has attracted a lot of business into the eThekwini area.

Chapter 7

RESULTS AND DISCUSSION

7.1 SG Maturity Assessment

7.1.1 Overview of the eTE SG Maturity Assessment

An invitation was extended by South African SG Initiative (SASGI) to all metropolitan municipalities in South Africa to be considered for the first SG Maturity Model (SGMM) assessment. eTE was chosen for this assessment which was to be sponsored through the South African National Energy Development Institute (SANEDI). eTE is the leading municipal electricity distributor in South Africa and is an active member of SASGI.

This chapter focuses on the assessment that was conducted at eTE and will make particular reference to and is a summary of the report compiled by SANEDI for this purpose.

Considering the major power grid changes experienced throughout the world as well as the local industry related challenges, South Africa identified the deployment of SGs as a key enabler to unlock the electricity supply industry (ESI) value, to improve service delivery and to position the industry to meet the future requirements [33]

SANEDI is a state owned company that is accountable to the Department of Energy and has been charged with the responsibility of establishing a SG Vision for South Africa and to direct and oversee all national efforts to accomplish the laid down vision [33]. SANEDI had carried out a comprehensive assessment of the current situation and evaluated various options and models to assess and get a measure of the SG maturity levels of an electricity distribution utility and chose the Carnegie Mellon SG Maturity Model (SGMM) as the preferred option though endorsement from SASGI which is a body established through SANEDI to promote and facilitate cooperation within the industry with particular respect to the roll-out of SG technology applications.

There is a limited ability to promote effective customer engagement and proactive participation at the lower voltage levels of distribution systems in the South African context due to limited implementation of SG technology. This is however, much less of a challenge with the transmission grid and the higher voltage distribution levels.

According to the National Energy Technology Laboratory (NETL) the following should be principle characteristics of a SG: [33]

- Encourage consumer participation
- Accommodate all generation sources
- Accommodate all energy storage options
- Optimize asset utilization
- Maximize efficiency

- Resilient to attack and natural disasters
- Encourage new products, services, and markets

7.1.2 SGMM Background

The SGMM is fundamentally a management support tool that provides a common language and framework; for defining key elements of SG transformation and helping utilities develop a programmatic approach and to track their progress [33]. The original development of the SGMM was initiated by a group of key electricity industry representatives from the United States of America (USA) and dates back to 2007.

The results obtained through the model could assist a utility to gain a better understanding their current status and of their SG deployment capability. The model could also assist to establish realistic future aspirations and give an indication of what is required to achieve this and the implications thereof. According to the report, the model and the results obtained through the model can be leveraged to:

- Establish a shared picture of SG objectives
- Communicate the SG vision internally as well as externally
- Establishing a strategic framework
- Benchmarking
- Develop a specific roadmap or way forward
- Prioritize current initiatives, opportunities and projects
- Decision making tool for investment considerations
- Resource evaluation
- Evaluation and measurement of progress.

The Carnegie Mellon Software Engineering Institute is currently the Steward of the SGMM and their roles and responsibilities include: [33]

- Providing governance
- Enabling widespread use of the model
- Evolving and revising the model based
- Developing training, collaboration and research to support the model
- Increasing the size of the SGMM community

As per the report, a total of 142 utilities have submitted 155 SG submissions since 2008 and the model has been through various phases of enhancement. The model could therefore be classified as dynamic as the design can accommodate trends and best practices applicable to the international electricity supply industry. Refer to annexure for a full list SGMM Community Participants.

7.1.3 The SG Maturity Model

As per the report this description is for the Model (V1.2) and consists of a product suite that includes the following: [33]

- The Model
- Compass Assessment Survey
- Navigation Process
- Training
- Partner Program

The SGMM is structured into eight domains, six maturity levels and 175 characteristics. It is designed to facilitate a logical, systematic and focused approach which enables the coordinator to effectively lead the participants through the assessment. The intention is to focus on a holistic business approach and not to rate or rank dimensions of the business in respect of importance.

7.1.3.1 Domains

The eight domains as stipulated in the model are grouped logically in terms of SG characteristics and capabilities for which a maturity progression is defined. Domain specific questions are to be used to ascertain a rating for the utility within the respective domain. One domain specific question is allocated to each characteristic. The domains and focus areas as outlined in table 7.1:

Table 7.1: Table: Domains and Focus Areas [33]

Domain	**Focus**
Strategy, Management & Regulatory (SMR)	Vision, planning, governance, stakeholder collaboration.
Organization & Structure (OS)	Culture, structure, training, communications, knowledge management.
Grid Operations (GO)	Reliability, efficiency, security, safety, observability, control.
Work & AM (WAM)	Asset monitoring, tracking & maintenance, mobile workforce.
Technology (Tech)	IT architecture, standards, infrastructure, integration, tools.
Customer (Cust)	Pricing, customer participation & experience, advanced services.
Value Chain Integration (VCI)	Demand & supply management, leveraging market opportunities.
Societal & Environment (SE)	Responsibility, sustainability, critical infrastructure, efficiency

7.1 3.2 Maturity Levels

The model consists of six defined maturity levels which represent very specific stages of the utility's progress towards achieving its SG vision. The maturity levels within a domain are designed to build on the previous level and it is essential that a utility must achieve maturity in the preceding level in order to achieve maturity in the next level. In establishing the target maturity for a specific utility the focus is on targets relevant to that particular utility and based on its own profile and own business objectives over a defined time period. The six maturity levels are outlined in table 7.2:

Table 7.2: Maturity Levels [33]

Level	**Description**
Level 5: Pioneering	Breaking new ground; industry-leading innovation.
Level 4: Optimizing	Optimizing SG to benefit entire organization; may reach beyond organization; increased automation.
Level 3: Integrating	Integrating SG deployments across the organization, realizing measurably improved performance.
Level 2: Enabling	Investing based on clear strategy, implementing first projects to enable SG (may be compartmentalized).
Level 1: Initiating	Taking the first steps, exploring options, conducting experiments, developing SG vision.
Level 0: Default	Default level (status quo).

7.1.4 SG Maturity Assessment Process

The process has to be facilitated by an SEI-certified Navigator and consists of five clearly defined steps. The key tasks of the Navigator are a coordination role and include the facilitation of the utility through the process and to assist the participants in understanding the model and to establish the current status of the utility against the model. The Navigator for the process conducted at eTE was Dr Willie de Beer who is a Specialist Energy Industry Consultant and this was done in conjunction with SANEDI. The five steps are listed and discussed below:

- Preparation
- Survey Workshop
- Analysis
- Aspirations Workshop
- Wrap Up

During the preparatory phase the maturity assessment process was planned, roles and responsibilities were defined and key utility data was collected. This step was critical to ensure the effective execution of the process.

The Compass Survey Workshop was the next step in the process. It was vitally important to reach consensus during this workshop as the answers collected from the utility and the inputs received reflected a collective view of the participants.

The Analysis phase was next up and this was where Navigator analyzed the results and provided findings based on his experience, knowledge of eTE and broader understanding of the business.

An Aspirations workshop was then convened and the Navigator delivered the results and his observations to the utility. Specific aspirations that are aligned with the organization's goals and objectives were defined by the participants and timelines were established to realize those aspirations.

The Wrap Up phase required the Navigator to provide the utility with a final presentation and to provide the prescribed documentation to the SEI.

7.1.5 SGMM Results

The pie-chart in figure 7.1 reflects the SGMM Community. The Community represents all of the entities and utilities who have participated in the SGMM process to date. The chart indicates that global participation in the process is on the increase, which directly contributes to the enhanced representative status of the model. It can be seen that the community is predominantly US based and then a more-or-less equal split between countries located in Europe, Middle East and Africa (EMEA), Asia Pacific and countries listed as other. Annexure A includes a complete list of participants in the SGMM Community.

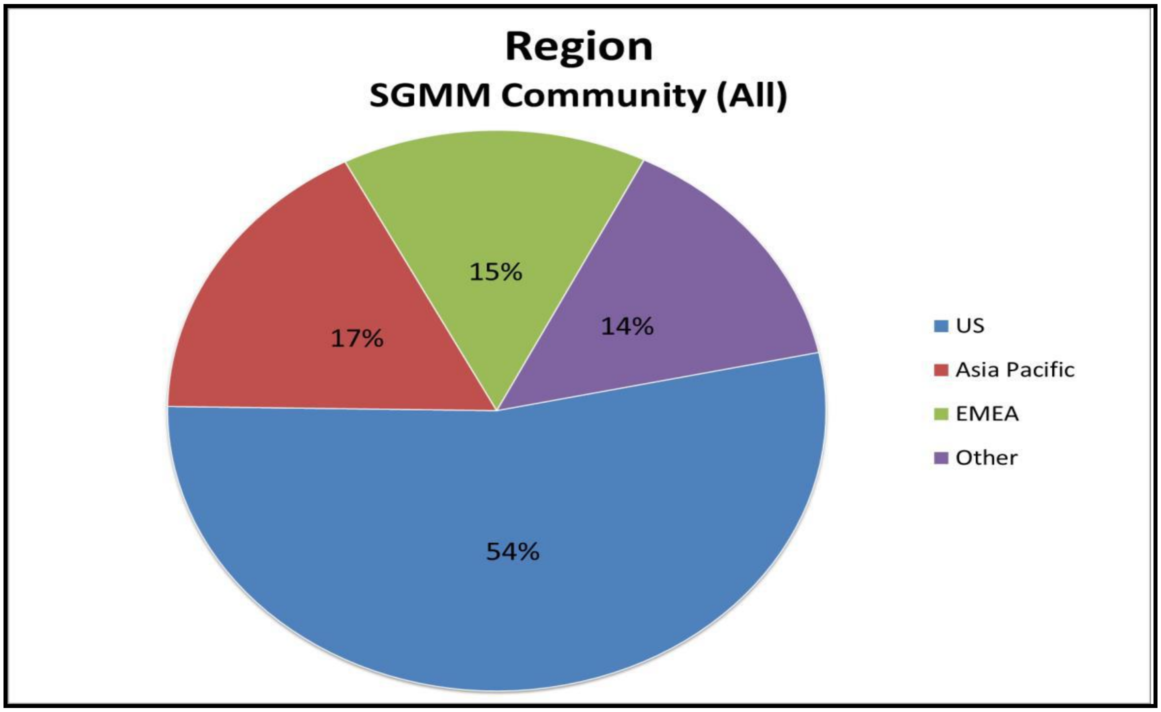

Figure 7.1: SGMM Community [33]

The following generic observations were made by the Navigator which was based on the analysis of results received from SEI and his insight and knowledge: [33]

- A large number of technology implementation initiatives are taking place within eTE;
- The technology implementation initiatives are not necessarily aligned and integrated into a SG strategy;
- The survey results reflect the absence of an integrated technology deployment approach as many projects were being carried out independently.
- The approval and adoption of a SG vision, implementation strategy and technology deployment plan will significantly elevate the SG maturity level of the eTE;
- Employee participation and the business structure alignment to support the SG journey is of vital importance;
- eTE demonstrated commitment to the SG maturity assessment process and the participation was commendable.
- While the utility's SG maturity level lags the Peer Community as well as that of the SGMM community, there is a level of correlation.
- The trend gap in respect of the Organization & Structure (OS), Technology and Societal & Environment (SE) however indicated a larger lag when compared to the Peer Community.

- The results dashboard also reflected that there are a number of domains where significant progress towards higher maturity levels is present, e.g. Strategy, Management & Regulatory (SMR), Technology and SE.
- Particular attention is required in respect of the number of levels where initial progress towards the requirement for higher maturity levels are evident without meeting level 1 in the OS and Customer domains.
- The maturity level in respect of the Customer domain somewhat did not dovetail with the utility's stated objectives;
- The Grid Operations (GO) and the Value Chain Integration (VCI) indicated significant maturity and were closest to the Peer and the SGMM community.
- It was suggested that supporting data and availability in respect of recognized utility performance indicators e.g. CAIDI, CAIFI, SAIDI, SAIFI, MAIFI, etc. be investigated and introduced.
- The unplanned outage related figures were excessive and it was suggested that advanced distribution and outage management systems integrated into a holistic AM system would yield positive results.
- The documentation and recording of the relevant information e.g. information supporting the utility dashboard should be confirmed and established.
- The high focus on information security from the outset on all projects was commendable
- The results and the survey, in terms of the maturity profile for eThekwini indicated that the utility was at the start of its SG maturity journey and there were areas where measurable progress is evident in the deployment of SG enabling technologies.

A summary of the results of the maturity exercise is illustrated in figure 7.2. It can be seen that eTE obtained 0s in all categories except for Grid Operations. This does not mean necessarily mean that nothing is being done in the other areas, but rather that the initiatives are still too early in their development to warrant a higher rating.

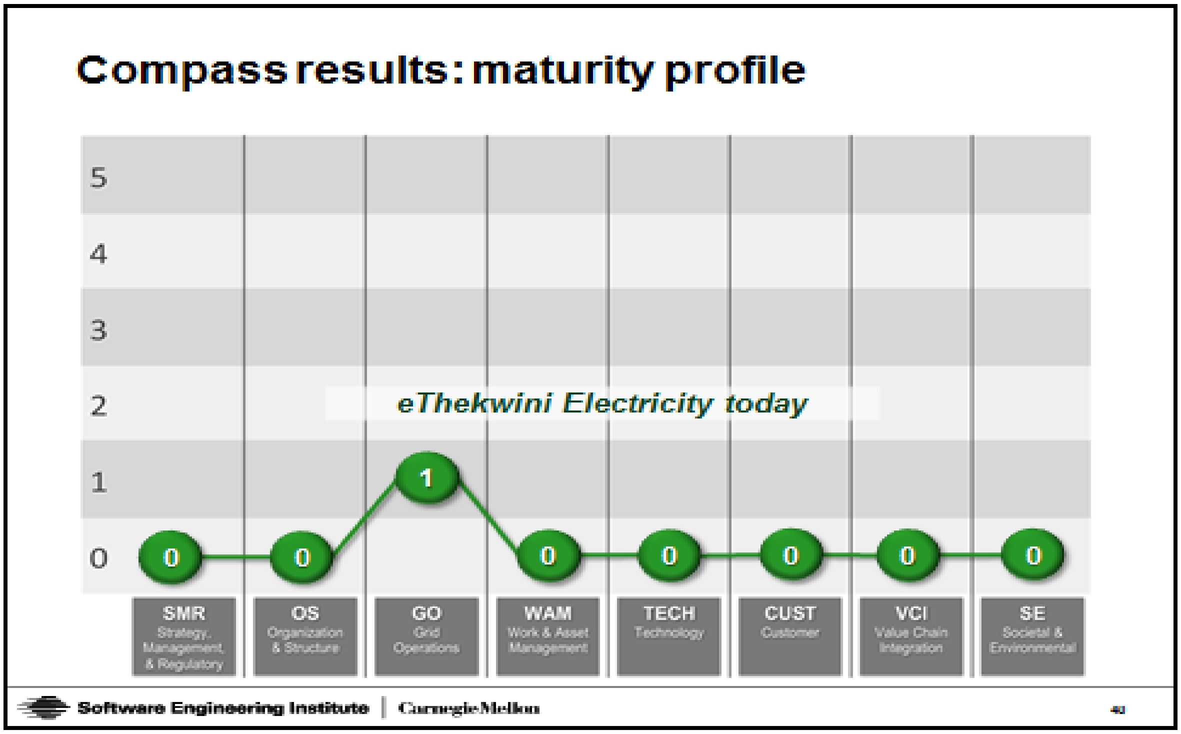

Figure 7.2: eTE SG Maturity Profile [33]

Annexure B provides detailed results per domain. The summary of the reports is as follows: [33]

7.1.5.1 Strategy Management & Regulatory (SMR)

In this domain the maturity of eTE was measured in respect of the business strategy, management and regulatory relationship. The absence of a documented and approved SG vision, business plan and strategy impacted negatively on the maturity level within this domain. It was advised for eTE to address the following areas:

- The SG strategy and technology deployment must address the operational improvement of the utility
- The SG strategy and technology deployment must be underpinned with the required approved budget
- The SG vision must be communicated and accepted across the organization
- Engagement with the regulator and key stakeholders in respect of the SG vision;
- A SG governance model and authorized leaders will significantly contribute to the maturity within this domain.

7.1.5.2 Grid Operation (GO)

In this domain the maturity of eTe was measured in respect of the grid reliability, efficiency, security, safety, observability and control. The results indicated the following:

- Advanced technology deployment such as substation automation, advanced outage restoration, remote asset monitoring, advanced data communication, etc. will significantly contribute to the maturity growth in this domain;
- The availability and use of SG information by all the relevant stakeholders across the business is essential for maturity progress
- Fact-based use of grid data is critical to ensure effective grid operations and domain maturity
- Smart meters must be leveraged as grid management sensors in the network, or else a less than optimal return on the investment may result
- Grid data should be used to support physical and cyber security.

7.1.5.3 Work and AM (WAM)

The maturity of eTE was measured in respect of asset monitoring, tracking, maintenance and the deployment of a mobile work force application. It was advised that the following be paid attention to:

- A comprehensive documented asset & workforce management policy and strategy will lay the foundation for remarkable maturity growth in this domain
- Alignment with the SG vision and strategy of eTE
- SG capabilities should be leveraged to track inventory and manage event history
- The development and implementation of an integrated mobile workforce strategy is essential for maturity growth in this domain
- A comprehensive performance, trend analysis and event capability is required.

7.1.5.4 Technology (Tech)

The maturity of eTE was measured in respect of the deployment of technology, IT/OT architecture, standards, infrastructure, integration and tools. The results indicated that:

- A well-defined enterprise ICT policy, strategy and implementation plan is required to leverage technological benefits for SG. The absence of an approved SG vision directly impacts on the ability to promote alignment between the ICT strategy, IT architecture and the SG vision;

- A data communication strategy for the grid must be developed and approved
- Technology applications that will enhance business performance and sustainability should be identified and aligned with the SG vision

7.1.5.5 Customer (Cust)

The maturity of eTE was measured in respect of customer participation, customer expectation, pricing and advanced services. The results suggested the following:

- Various initiatives were at the stage of “initial progress towards requirements for a specific level.”
- It appears as if the initiatives were not informed by an integrated SG vision;
- An evaluation of the current initiatives, alignment with the SG vision and prioritization of these will benefit eTE
- Technology applications be identified and deployed which will enhance the customer benefits and improve participation
- The SG vision and technology deployment be communicated to the customers
- Deployment of SM capabilities and the ability of customers to access data and respond to environmental, economic and utility signals will substantially contribute to the growth in maturity in this domain

7.1.5.6 Societal & Environmental (SE)

The maturity of eTE was measured in terms of its response to the environment, sustainability, critical infrastructure and efficiency. The results indicated the following:

- The absence of an approved SG vision negatively impacted on the maturity eTE
- The role of eTE and the goals, objectives and targets in respect of the societal and environmental domain be reflected in the SG vision and strategy
- Consideration must be given as to how the deployment of a SG can positively contribute to plant and network reliability, health, safety, security and effective energy management
- eTE should actively engage in addressing societal and environmental matters and accommodates multiple renewable energy options to improve maturity

7.1.5.7 Value Change Integration (VCI)

The maturity of eTE was measured in respect of demand and supply management as well as the ability to leverage market opportunities. In order to increase maturity in this domain, the results indicated the following:

- eTE must leverage near real-time information/data to promote dynamic supply and demand management as well as information sharing within the value chain
- eTE to move from the stage of documenting and approving initiatives to the implementation, evaluation and identification of best practices
- Further identification and implementation of energy storage and DG options will contribute to maturity growth
- A well defined, integrated and implemented AMI business case will benefit the utility and contribute to maturity growth

7.1.5.8 Organization and Structure (OS)

The maturity of eTE was measured in terms of the business culture, structure, training, communication and knowledge management. The key findings were as follows:

- The lack of a clearly defined communication strategy in support of an approved SG vision negatively impacted on the maturity level
- There is a need to identify the required competencies and resources to build the required capacity in the workforce;
- The SG vision should drive the focus, investments and change at eTE
- Cross functional resource deployment, alignment of training and development initiatives as well as performance assessment and compensation linked to the SG strategy is required for maturity growth.

7.1.6 SGMM Aspirations

An Aspiration workshop was conducted on at 11 February 2014 and it was coordinated by Dr Willie de Beer who is a Specialist Energy Industry Consultant and Dr Minnesh Bipath who is the Acting CIO at SANEDI. A total 33 people attended the session where the SGMM results were discussed. The focus then moved to the Aspiration target setting and an Aspiration time line of 5 years was agreed upon. Each of the eight domains was considered, the future potential maturity growth debated and consensus reached on the aspiration target. The meeting then agreed on the following:

- What motivates the aspiration?
- What action must happen to achieve the aspiration?

- What obstacles must be overcome to achieve the aspiration?

The illustration in figure 7.3 reflects the aspiration targets for eTE projected over a 5 year period. Full details of the aspirations and actions per domain are reflected in Annexure C which lay a sound foundation for eTE to realize in an integrated manner its SG objectives.

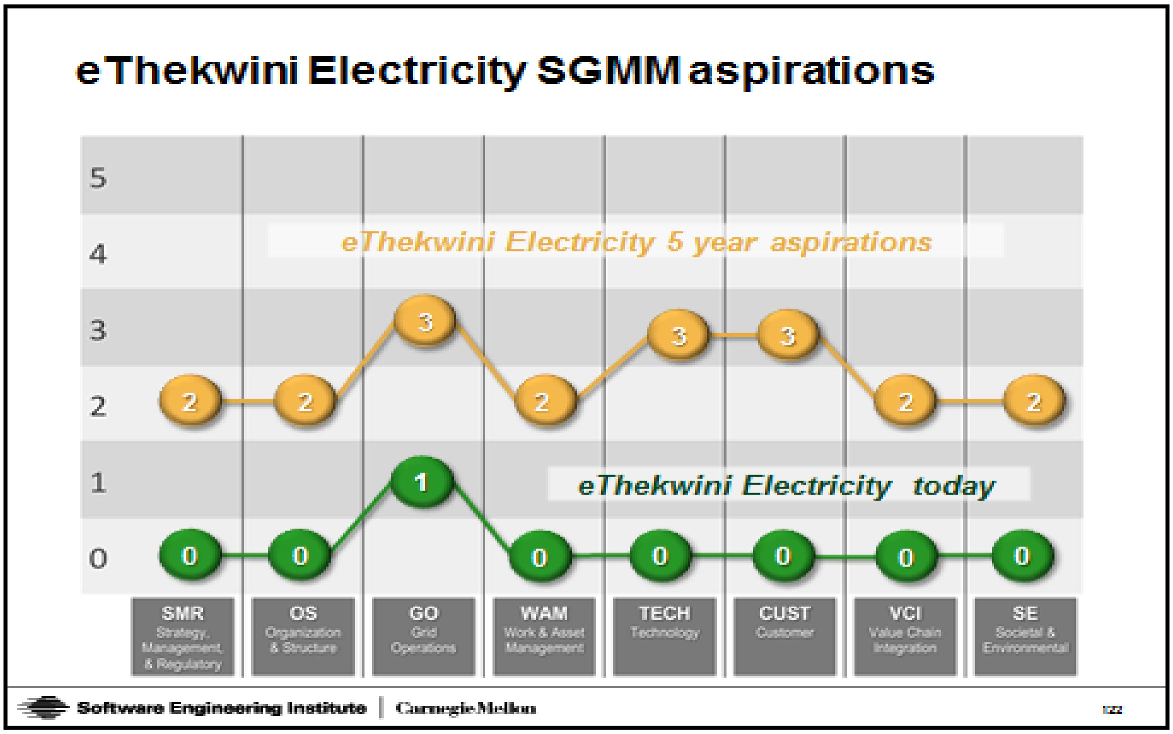

Figure 7.3: eTE SGMM Aspirations [33]

7.1.7 Summary of the SGMM Process

The process assisted in developing a realistic picture in respect of the SG maturity level of eTE. The process recognized the initiatives currently receiving attention and assisted in putting it in context within the SG maturity journey. It was also pointed out that it is important that the "silo approach" be addressed and that the SG vision is approved as a matter of urgency. In the absence of an approved vision and alignment with investment and technology deployment alignment, eTE runs the risk in not achieving the business objectives. It was recommended that a governance structure be put in place to monitor and report on the progress in respect of the SG maturity journey. The development of employees and the identification of talent to meet the capability to realize the SG opportunities were classified as of utmost importance [33].

7.2 Research Answers from SGMM Assessment

At the beginning of the study, it was stated that the research question will address as to how eTE's SG maturity levels compare to these and other countries, whether the SG Technology deployment is aligned with its objectives, to ascertain the level of impact of SG implementation and whether the anticipated benefits are being realized at eTE.

The SGMM assessment was extremely beneficial for eTE in that it exposed and compared the organization to local and international counterparts. It has however, emerged that eTE is still at the very early stages of SG maturity when compared to the peer and SGMM community. The results indicated that there were, however significant progress in some domains. It also emerged that the lack of a of a formalized SG vision, implementation strategy and technology plan resulted in various initiatives not been aligned to its objectives. This has therefore become one of the organizations main focus areas. The level of impact of SG systems varies in different areas of the business and the rollout of the SM project will provide more tangible data, especially from a consumer enablement perspective. The organization is realizing some benefits of the SG systems; however this is a scope of much larger scale benefits as the maturity levels increase.

Conclusion

The purpose of the study was to look at the various deployment initiatives of SG technologies and the individual and overall impact of these initiatives. It is quite clear that eTE is extremely progressive in its approach and has embraced the concept of SG and is striving to become one of the leaders in SA in this regard.

Communication Systems

The Communication Systems fairs favorably when compared to first world standards and caters for all communication requirements across the various SG applications. It was however, picked up that eTE is still quite dependent on the ageing pilot copper network for a lot of the communication applications, and the transition to the more modern communication technologies may prove to be the biggest challenge in this area.

DA at MV/LV Level

There are currently many DA initiatives and projects that are being implemented across eTE and progress is at an advanced stage in many areas. The major benefits arising out of the DA initiatives in the context of SG is the increased visibility of the electrical system and the ability to remotely control, operate and monitor the electrical network.

DA at HV Level

The DA projects at HV are sometimes referred to as Transmission Automation (TA) for the purpose of this study to differentiate initiatives at the various classified voltage levels on the system as per the organizational structure. Similar to DA, there are currently many TA initiatives and projects that are being implemented across eTE and progress is at an advanced stage in many areas. The major benefits arising out of the TA initiatives is the increased visibility of the electrical system and the ability to remotely control, operate and monitor the electrical network

DG

The eThekwini Municipality has embarked on various RE and DG projects that support SG and the impact of these are quite minimal at this stage when compared to generation capacity and energy consumption trends. The principles of the various technologies of RE and DG are, however being demonstrated and has paved the way for future development and larger scale implementation in the future. The various projects prove that eTE has accepted that DG is now an integral part of the system and has shifted its mindset in embracing this concept.

Smart Street Lighting

The implementation of small scale Smart Lighting systems at eTE has demonstrated that there is potential for huge development and benefits in this area. The move from HID to LED technologies provides huge energy savings in itself and further benefits could be achieved by intelligently controlling and monitoring these lighting systems. The big question mark in this area is the reliability and the ability of these mostly electronic and microprocessor based systems to withstand the harsh climatic and environmental coastal conditions over prolonged periods. The high vibration levels, especially in the industry intensive areas will pose further challenges to these systems.

SM

SM is probably the area where the benefits of SG systems can be most clearly demonstrated. It is however, extremely unfortunate that when this study was conducted, eTE was still at a very embryonic stage in this regard. eTE is making huge strides in achieving its SM objectives but it will be at least a few years until the required communication systems are in place and the relevant SM system implemented to see the benefits of these systems.

AM

The AM reports provide a clearer picture of the state of the electrical network and the seriousness of the challenges facing the organization. There is a huge disparity between tactical and non-tactical maintenance which indicates that field staff are concentrating more of their efforts on faults and breakdowns, thereby neglecting the planned maintenance work. The lack of planned maintenance work ultimately results in more faults and breakdowns and this coupled with the huge volumes of theft, vandalism and third party cable damage poses serious challenges for the municipality. The AM and SG systems are however, providing the organization with a much clearer picture of the situation.

System Performance Indicators

The technical system performance indicators shows a progressive increase in overall performance for the periods under review, but it must noted that the worst performance was experienced two financial years ago in 2013 due to a large number of faults. The measurement of SMn is probably the best indicator of overall performance as it is an indicator of the period that energy is not supplied. It can be concluded that in this regard, the SG systems are starting to have a positive impact on the electrical network.

Statistical Data Analysis

The financial statistics indicates a fairly static capital budget spend which indicates that eTE is somewhat progressive in this regard but there is only a slight increase year on year. This is actually misleading as eTE had actually intended to spend much more on capital projects but had to declare significant savings due to corporate instructions. The operating budget, on the other hand is on a constant uptrend, largely owing to the large number of faults that occur on the network. As indicated earlier in this study, one of the main objectives of the implementation of SG systems is to drive down costs. The financial statistics however indicate results to the contrary. This does not necessarily mean that SG is not having a positive impact on the system, but rather that there are many more factors that are driving up the costs that are beyond the control of the SG systems.

Electricity Tariffs

The electricity tariffs are also on a constant uptrend for the industrial, commercial and residential customers. eTE is however, classified as an electricity distributor as it purchases electricity from Eskom and thereafter sells to its customers. In order to make this transaction feasible and sustainable, the eTE tariffs are to some extent a reflection of the Eskom tariffs and any price increase imposed on by Eskom will have a resultant increase in the eTE tariffs. It was also pointed out earlier in the study that an objective of the implementation of SG is to make services more affordable to the consumers, however the consistent increase in tariff rates indicates otherwise. The other method where consumers could save money is by better managing their load requirements and power consumption. There is already a TOU tariff available for the industrial and commercial customers where consumers could enjoy significant savings by moving their loads into the standard and off-peak periods and the metering infrastructure is already in place to support this. A residential TOU tariff was published and advertised approximately four years ago, but the metering infrastructure is unfortunately not yet in place to support this tariff. As indicated earlier, eTE is putting in a great effort to rectify this so that the residential customers could enjoy the benefit of a flexible tariff.

System Losses

The overall system losses dropped from around 8% in 1999 and has averaged between 4.5 to 6% from then till date. It is however, noted that there has been a steady uptrend over the past seven financial years and this is cause for great concern as it is largely an indicator of the increase in volumes of illegal electricity connections. The SG systems are able to detect these anomalies in the systems but the socio-economic battle is a far greater challenge for the municipality.

SGMM Assessment

This exercise was extremely beneficial for eTE in that it exposed and compared the organization to local and international counterparts. The process was fairly comprehensive and involved most of the relevant role players with regards to SG. The results, however proved to be an extremely harsh reality as to where exactly eTE is with regards to its SG maturity. These results were however derived from a particular model and a specific navigator. It would be rather interesting and a great area for further research to run an assessment on the eTE system with another model. The five year aspirations are very realistic and the eTE now knows exactly where they currently are, where they need to be and what is required to get there in terms of SG maturity?

Limitations of the Study

The following were noted as limitations of the study:

- **Non-Specific Area**
  The study was limited in terms in that it was not conducted in a specified area but rather on the overall electrical network. SG systems were implemented across the city in different form and applications and it was quite difficult to focus on specific areas.

- **Financial Budgets**
  The financial budgets were also looked at from an overall perspective and not separated specifically into the category of SG.

- **Lack of SM Infrastructure**
  The lack of SM infrastructure, especially in the residential sector did not provide the opportunity to demonstrate the benefit of SG implementation from a consumer enablement perspective.

- **Omission of Smaller Scale SG Projects**
  The study highlighted only the main SG initiatives that currently stand out in the system, and may have omitted smaller scale projects that could contribute to this initiative.

Areas for Further Research

The following are potential areas for further research from a SG perspective:

- The impact of SG on electrical protection systems
- SG maturity assessments on different models
- The impact of SCM and procurement policies on SG
- Change management and communicating behavior change from a SG perspective
- Alleviating energy poverty with SG systems

Recommendations

The following are recommendations emanating from this study:

- eTE formally compile and adopt a SG policy and strategy, which should include the vision, objective and mission statement.

- A dedicated budget should be created, monitored and controlled for SG activities and initiatives.

- eTE should focus on leveraging SM as a grid management sensor in the network, or the true benefit of SG may not be realized and a less than optimal return on the investment may result.
- The development and implementation of an integrated mobile workforce strategy should feature highly on the eTE agenda.

- Cross functional resource deployment, alignment of training and development initiatives as well as performance assessment and compensation linked to the SG strategy is required for maturity growth.

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South African National Energy Development Institute.

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eThekwini Electricity Smart Grid Maturity Assessment

February 2014

5 ANNEXURE A: 140 SGMM Community Participants

AES Electropaulo
Alameda Municipal Power
Allegheny Power
Alliander
Ameren Illinois
Ameren Missouri
American Electric Power
APCPDCL
ATCO Electric
ATCO Gas
Ausnet
Austin Energy
AZUSA Light and Water
BC Hydro
BESCOM
Bonneville Power Admin.
BSES- Rajdhani
Burbank Water and Power
CELPE
CenterPoint Energy
Centro Sur
CESC Limited
CESC, Mysore
CFE (Mexico) Gulfonorte
CFE (Mexico) Jalisco
CFE (Mexico) Peninsular
Chelan County PUD
CitiPower and Powercor Australia Ltd
City of Anaheim
City Of Columbus
City Of Danville
City Of Dover
City Of Hamilton
City Of Hudson
City Of Jackson
City Of Napoleon
City Of Painesville
City Of Palo Alto
City Of Piqua Power System
City of Riverside Public Utilities
City Of Wapakoneta
City Of Westerville
CLP Power
Coldwater Board Of Public Utilities
Country Energy
CPFL Paulista
Dhofar Power Company S.A.O.C.
Dominion Virginia Power
DONG Energy Sales & Distribution A/S

Guandong Power Co.
Holland Board of Public Works
Hydro One
Hydro One - Distribution
Hydro Ottawa Limited
IEC
Imperial Irrigation District
Integral Energy
Intergys
Jamaica Public Service Company
KEPCO
Los Angeles Department of Water and Power
MAJAN ELECTRICITY COMPANY S.A.O.C.
Manila Electric Company
Manitoba Hydro - T&D
Marietta Board of Lights and Water
Mazoon Electricity Company
Memphis Light, Gas and Water Division
MSEDCL
Muscat Electricity Distribution Company S.A.O.C
Muscatine Power & Water
Nashville Electric Service
NB Power
NDPL
NOIDA POWER COMPANY LIMITED
Oberlin Municipal Light & Power System
OMAN ELECTRICITY TRANSMISSION CO.
Pasadena Water and Power
Pepco Holdings/PHI
PG&E
PGN Carolina
PGN Florida
PNM
Portland General Electric
PPL Electric Utilities
Princeton Electric Plant Board
Puget Sound
Redding
Roseville Electric
RURAL AREAS ELECTRCITY COMPANY.
Sacramento Municipal Utility District
Salt River Project
Santee Cooper
SCANA
SDG&E
SIG Geneva
Silicon Valley Power
SMEPC - International Cooperation Dept.
Snohomish

DPSC Limited
DTE Energy
Duke Energy
Eandis
East Miss EPA
EDF Energy Networks Branch
EDP - Energias do Brasil, S.A.
EnergyAustralia
Enexis
Entergy
EPCOR Distribution & Transmission
Ephrata Borough
ERDF
ESB Networks
Eskom Holdings SOC Limited
eThekwini Municipality, Electricity Unit
Exelon/ComEd
Exelon/PECO Energy
FirstEnergy
Fortum
Glendale Water & Power
Southern Company
Tata Power
Tenaga Nasionale Berhad
Tokyo Electric Power Co.
Toronto Hydro Electric System Ltd.
Town Of Front Royal
Tucson Electric Power
UGVCL
Unión Fenosa Distribución
Unison Networks Limited
Vattenfall Distribution
VELCO
Village Of Carey, Ohio
Village Of Clinton
Village Of Oak Harbor
Village Of Yellow Springs
Wadsworth Electric And Communications
Wyandotte Municipal Service
Xcel Energy
Yantarenergo
Zhejiang Jiaxing Electric Power Bureau

6 ANNEXURE B: Results per Domain

Domain: Strategy, Management & Regulatory (SMR)

	eThekwini Municipality, Electricity Unit	SGMM Peer Community Data (≥250K Meters)		SGMM Community Data (All)	
		Count	Distribution	Count	Distribution

Strategy, Management, and Regulatory (SMR)
Level 1: Initiating

SMR-1.1 Has your organization developed a smart grid vision that addresses operational improvement?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		8	24%	29	35%
B. Within a single function (or line of business)	X	4	12%	13	16%
C. Across multiple functions (encompasses and is communicated across multiple functions)		12	35%	26	32%
D. Across the organization (encompasses and is communicated across all functions in the organization)		10	29%	14	17%

SMR-1.2 Are experimental implementations of smart grid concepts supported within your organization?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		1	3%	7	9%
B. Limited experimentation with limited organizational support		4	12%	19	23%
C. Significant experimentation with limited organizational support		9	26%	14	17%
D. Limited experimentation with strong organizational support	X	11	32%	25	30%
E. Significant experimentation with strong organizational support		9	26%	17	21%

SMR-1.3 Have you had discussions with regulators about your smart grid vision?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No	X	4	12%	26	32%
B. Limited informal discussions have been held		14	41%	32	39%
C. Extensive discussion have been held		16	47%	24	29%

Level 2: Enabling

SMR-2.1 Has an initial smart grid strategy and business plan been approved by executive management?

A. No		6	18%	22	27%
B. In development	X	11	32%	30	37%
C. Provisionally approved		5	15%	11	13%
D. Formally approved		12	35%	19	23%

SMR-2.2 Is a common smart grid vision accepted across your organization?

A. No		9	26%	28	34%
B. Within a single function and/or line of business		4	12%	15	18%
C. Across multiple functions and/or lines of business	X	16	47%	29	35%
D. Across all functions and/or lines of business		5	15%	10	12%

SMR-2.3 Are your organization's operational investments aligned to the smart grid strategy and business plan?

A. No		5	15%	23	28%
B. Partial, indirect alignment (not driven specifically from smart grid)	X	15	44%	36	44%
C. Partial, explicit alignment (driven from smart grid)		8	24%	13	16%
D. Significant, explicit alignment		6	18%	10	12%

SMR-2.4 Are budgets established specifically for funding the implementation of the smart grid?

A. No		28	31%	55	39%
B. Very limited (<30% of estimated need for current funding year)	X	36	40%	50	36%
C. Moderate amounts (30% - 70%)		8	9%	9	6%
D. Extensive (>70%)		18	20%	26	19%

SMR-2.5 Is your organization collaborating with regulators and other stakeholders about your smart grid vision and strategy?

A. No	X	18	20%	45	32%
B. With stakeholders only		19	21%	29	21%
C. With regulators only		9	10%	11	8%

D. With both stakeholders and regulators		44	49%	55	39%

SMR-2.6 Is support and funding provided for conducting smart grid proof-of-concept projects (e.g., AMI, DG)?

A. No		1	3%	12	15%
B. Limited with informal funding and support		7	21%	24	29%
C. Significant with informal funding and support		0	0%	4	5%
D. Limited with formal funding and support	X	17	50%	23	28%
E. Significant with formal funding and support		9	26%	19	23%

Level 3: Integrating

SMR-3.1 Has your smart grid vision, strategy, and business case been incorporated into your organization's vision and strategy?

A. No		26	29%	57	41%
B. Somewhat	X	46	51%	61	44%
C. Extensively		13	14%	15	11%
D. Completely		5	6%	7	5%

SMR-3.2 Have you established a smart grid governance model for smart grid management and decision-making roles, processes, and tools?

A. No		13	38%	46	56%
B. Partial		11	32%	20	24%
C. Yes, a standalone model	X	4	12%	6	7%
D. Yes, integrated into existing governance model		6	18%	10	12%

SMR-3.3 Do you have one or more smart grid leaders with explicit authority across functions and lines of business to ensure proper implementation of smart grid strategy?

A. No		11	32%	32	39%
B. Multiple leaders, but lacking clear alignment or boundaries	X	11	32%	25	30%
C. Multiple leaders, aligned		9	26%	14	17%
D. Single leader		3	9%	11	13%

SMR-3.4 Have required authorizations for smart grid investments been secured from stakeholders (e.g., regulators, stockholders, tax payers)?

A. No		8	24%	33	40%
B. Indirectly	X	10	29%	16	20%

C. Partially		11	32%	22	27%
D. Explicit and complete		5	15%	11	13%

Level 4: Optimizing

SMR-4.1 Does your smart grid vision and strategy drive strategy and direction at the highest level (e.g., enterprise or corporate level)?

A. No	X	14	41%	43	52%
B. Smart grid has limited or indirect impact		10	29%	21	26%
C. Significant and direct impact		6	18%	10	12%
D. Drives strategy		4	12%	8	10%

SMR-4.2 Is smart grid a core competency throughout your organization?

A. No	X	42	47%	76	54%
B. Across parts of the organization		43	48%	59	42%
C. Across the entire organization		3	3%	3	2%
D. Across the entire organization and drives future competency		2	2%	2	1%

SMR-4.3 Is your smart grid strategy communicated and revised collaboratively with external stakeholders, excluding some sensitive aspects?

A. No	X	16	47%	54	66%
B. Some stakeholders		11	32%	18	22%
C. All key stakeholders		4	12%	6	7%
D. All stakeholders		3	9%	4	5%

Level 5: Pioneering

SMR-5.1 Does your organization capitalize on smart grid as a foundation for the introduction of new services and product offerings?

A. No	X	20	59%	55	67%
B. Little		9	26%	15	18%
C. Moderately		3	9%	10	12%
D. Extensively		2	6%	2	2%

SMR-5.2 Do your smart grid business activities provide sufficient financial resources to enable continued investment in smart grid sustainment and expansion?

A. No	X	22	65%	55	67%
B. Partially		6	18%	17	21%
C. Yes, primarily through cost savings and efficiency gains		2	6%	3	4%
D. Yes, primarily through new products and services		1	3%	1	1%
E. Yes, primarily through optimized rate recovery		0	0%	1	1%
F. Yes, through a combination of the above		3	9%	5	6%

SMR-5.3 Have you implemented new business models as a result of smart grid capabilities?

A. No	X	23	68%	59	72%
B. Identified, but not yet implemented		8	24%	16	20%
C. At least one new business model implemented		1	3%	5	6%
D. Multiple implemented		2	6%	2	2%

Domain: Organisation & Structure (OS)

eThekwini Municipality, Electricity Unit	SGMM Peer Community Data (≥250K Meters)		SGMM Community Data (All)	
	Count	Distribution	Count	Distribution

Organizational Structure (OS)

Level 1: Initiating

OS-1.1 Has your organization articulated (communicated) its need to build smart grid competencies in its workforce?

Answer	eThekwini Municipality, Electricity Unit	Peer Count	Peer Distribution	All Count	All Distribution
A. No	X	4	12%	12	15%
B. Partially (communication has occurred in some parts of the organization)		23	68%	60	73%
C. Extensively (communication has occurred throughout the organization)		7	21%	10	12%

OS-1.2 Has your leadership demonstrated a commitment to change the organization in support of achieving smart grid?

Answer	eThekwini Municipality, Electricity Unit	Peer Count	Peer Distribution	All Count	All Distribution
A. No	X	8	24%	28	34%
B. Leadership has made public statements regarding their commitment for change		11	32%	23	28%
C. Leadership has taken actions, such as assigning resources and budget		15	44%	31	38%

OS-1.3 Have awareness efforts within the workforce been initiated to support your smart grid activities?

Answer	eThekwini Municipality, Electricity Unit	Peer Count	Peer Distribution	All Count	All Distribution
A. No		2	6%	14	17%
B. Within a single function and/or line of business		7	21%	21	26%
C. Across multiple functions and/or lines of business	X	18	53%	37	45%
D. Across all functions and/or lines of business		7	21%	10	12%

Level 2: Enabling

OS-2.1 Has your smart grid vision begun to drive change and affect related priorities (e.g., addressing the need for an adequately skilled workforce)?

A. No	X	11	32%	34	41%
B. Within a single function and/or line of business		7	21%	18	22%
C. Across multiple functions and/or lines of business		14	41%	28	34%
D. Across all functions and/or lines of business		2	6%	2	2%

OS-2.2 Has your organization aligned operations around end-to-end processes to leverage smart grid capabilities?

A. No	X	14	41%	39	48%
B. A little (a few end-to-end processes are aligned to leverage smart grid capabilities)		13	38%	31	38%
C. Moderately (several)		5	15%	10	12%
D. To a great extent (most or all)		2	6%	2	2%

OS-2.3 Do smart grid implementation and deployment teams include participants from all impacted functions and lines of business?

A. No		8	24%	32	39%
B. Partially (<50% of impacted groups)	X	10	29%	24	29%
C. Substantially (50 - 80%)		7	21%	12	15%
D. To a great extent (>80%)		9	26%	14	17%

OS-2.4 Have education and training activities to develop smart grid competencies been identified and made available?

A. No	X	8	24%	34	41%
B. In development		12	35%	23	28%
C. In place for at least one function and/or line of business		5	15%	13	16%
D. In place across multiple functions and/or lines of business		9	26%	12	15%

OS-2.5 Have you linked performance and compensation plans to the achievement of smart grid strategy milestones?

A. No	X	20	59%	62	76%
B. In documented plan including committed schedule and budget		1	3%	2	2%
C. In progress		6	18%	10	12%
D. Yes		7	21%	8	10%

Level 3: Integrating

OS-3.1 Is your smart grid vision and strategy driving organizational change (e.g., roles, interactions, compensation, hiring criteria)?

A. No	X	33	37%	60	43%
B. Indirectly		22	24%	32	23%
C. In one function and/or line of business		8	9%	13	9%
D. Across two or more functions and/or lines of business		22	24%	30	21%
E. Across all functions and/or lines of business		5	6%	5	4%

OS-3.2 Does your organization's measurement system incorporate smart grid measures (e.g., on balanced scorecard)?

A. No	X	35	39%	73	52%
B. Indirectly		18	20%	27	19%
C. In one function and/or line of business		12	13%	13	9%
D. Across two or more functions and/or lines of business		19	21%	21	15%
E. Across all functions and/or lines of business		6	7%	6	4%

OS-3.3 Are performance evaluation and/or compensation linked to smart grid success (i.e., tangible benefits resulting from smart grid deployment or application)?

A. No	X	19	56%	56	68%
B. For a few selected people		9	26%	16	20%
C. For all smart grid leaders		1	3%	1	1%
D. For all leaders		1	3%	2	2%
E. For all smart grid workers (leaders and staff)		4	12%	7	9%

OS-3.4 Does your leadership provide a consistent smart grid vision and strategy in both actions and communications?

A. No		22	24%	50	36%
B. To some extent (< 40% of your leaders, including managers)	X	35	39%	52	37%
C. Moderately (40% - 80%)		17	19%	20	14%
D. To a great extent (> 80%)		16	18%	18	13%

OS-3.5 Does your organization have a matrix or overlay structure to support smart grid activities?

A. No		31	34%	62	44%
B. Evaluation is under way	X	36	40%	49	35%
C. Evaluation is complete and no changes were needed to adapt to new smart grid capabilities		4	4%	4	3%
D. Evaluation is complete and changes are documented in a plan for implementation		2	2%	5	4%
E. Evaluation is complete and changes have been implemented		17	19%	20	14%

OS-3.6 Are your education and training programs aligned to exploit smart grid capabilities?

A. No	X	16	47%	46	56%
B. In at least one function and/or line of business		6	18%	15	18%
C. Across two or more functions and/or lines of business		11	32%	20	24%
D. Across all functions and/or lines of business		1	3%	1	1%

Level 4: Optimizing

OS-4.1 Are management systems and organizational structures capable of taking widespread advantage of the increased visibility and control capabilities provided through smart grid?

A. No	X	16	47%	38	46%
B. Limited		14	41%	33	40%
C. Largely		4	12%	10	12%
D. Yes		0	0%	1	1%

OS-4.2 Does your organization have end-to-end grid observability that can be leveraged by both internal and external stakeholders?

A. No	X	23	68%	64	78%
B. Limited (<60% of stakeholders)		7	21%	12	15%
C. Largely (60% - 90%)		2	6%	3	4%
D. Yes (>90%)		2	6%	3	4%

OS-4.3 Is decision making occurring at the closest point of need as a result of an efficient organizational structure and the increased availability of information due to smart grid?

A. No	X	19	56%	48	59%
B. Limited		9	26%	25	30%
C. Largely		4	12%	6	7%

D. Yes		2	6%	3	4%

Level 5: Pioneering

OS-5.1 Does your organizational structure enable collaboration with other grid stakeholders to optimize overall grid operation and health?

A. No		11	32%	34	41%
B. A little (the organization participates in some community-wide responses to grid health)	X	12	35%	30	37%
C. Moderately (the organization participates in most community-wide responses to grid health)		3	9%	9	11%
D. Yes (the organization is a leader in community-wide responses to grid health)		8	24%	9	11%

OS-5.2 Is your organization and its structure readily adapting to support new ventures, products and services as they emerge as a result of smart grid?

A. No	X	17	50%	35	43%
B. Limited		14	41%	38	46%
C. Largely		3	9%	7	9%
D. Yes		0	0%	2	2%

OS-5.3 Are channels established to harvest ideas, develop them, and reward those that help to shape future advances in process, workforce competencies, and technology?

A. No	X	14	41%	41	50%
B. Limited		15	44%	33	40%
C. Largely		2	6%	3	4%
D. Yes		3	9%	5	6%

Domain: Grid Operation

	eThekwini Municipality, Electricity Unit	SGMM Peer Community Data (≥250K Meters)		SGMM Community Data (All)	
		Count	Distribution	Count	Distribution

Grid Operations (GO)

Level 1: Initiating

GO-1.1 Do you have a business case for new equipment and systems related to smart grid for at least one business function (e.g., AMI, remote disconnect, PMUs, etc.)?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		10	11%	21	15%
B. In development		35	39%	51	36%
C. Approved	X	11	12%	18	13%
D. Being executed		34	38%	50	36%

GO-1.2 Are you evaluating new sensors, switches and communications technologies for grid monitoring and control?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		1	3%	6	7%
B. To some extent, not directly for smart grid		5	15%	23	28%
C. To some extent, for smart grid	X	11	32%	26	32%
D. To a great extent (i.e., numerous evaluations underway or completed)		17	50%	27	33%

GO-1.3 Do you have proof-of-concept projects and/or component testing for grid monitoring and control underway?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		5	6%	19	14%
B. To some extent, not directly for smart grid		25	28%	45	32%
C. To some extent, for smart grid	X	34	38%	46	33%
D. To a great extent (i.e., numerous evaluations underway or completed)		26	29%	30	21%

GO-1.4 Are you evaluating outage and distribution management systems linked to substation automation (beyond SCADA)?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		4	12%	24	29%
B. To some extent, not directly for smart grid		3	9%	17	21%
C. To some extent, for smart grid	X	15	44%	23	28%

D. To a great extent (i.e., numerous evaluations underway or completed)		12	35%	18	22%

GO-1.5 Are safety and security (physical and cyber) requirements considered in all grid operation initiatives?

A. No		5	6%	16	11%
B. Some (<50%)		14	16%	22	16%
C. Most (50% - 90%)	X	13	14%	16	11%
D. Yes, for essentially all initiatives (>90%)		58	64%	86	61%

Level 2: Enabling

GO-2.1 Have you implemented distribution to substation automation?

A. No		7	21%	29	35%
B. In documented plan including committed schedule and budget		2	6%	7	9%
C. In progress	X	10	29%	20	24%
D. Some completed (<70% of substations)		11	32%	15	18%
E. Many completed (≥70%)		4	12%	11	13%

GO-2.2 Are you implementing advanced outage restoration schemes that automatically resolve (self-heal) or reduce the magnitude of unplanned outages?

A. No	X	23	26%	59	42%
B. In documented plan including committed schedule and budget		20	22%	26	19%
C. In progress		34	38%	39	28%
D. Many completed (>20% of grid)		13	14%	16	11%

GO-2.3 Aside from SCADA, are you piloting remote asset monitoring of key grid assets to support manual decision making?

A. No	X	7	21%	38	46%
B. In documented plan including committed schedule and budget		5	15%	11	13%
C. Piloting		8	24%	15	18%
D. Pilots complete or technology being deployed		14	41%	18	22%

GO-2.4 Are you investing in expanded data communications networks in support of grid operations?

A. No	X	5	15%	19	23%
B. In documented plan including committed schedule and budget		5	15%	8	10%
C. In progress		7	21%	17	21%
D. Partially completed (in place and functioning for >20% of grid)		12	35%	18	22%
E. Largely completed (> 80%)		5	15%	20	24%

Level 3: Integrating

GO-3.1 Is smart grid information made available across systems and organizational functions?

A. No	X	9	26%	35	43%
B. In development		3	9%	12	15%
C. Available across a few functions and systems		16	47%	27	33%
D. Available across most functions and systems		6	18%	8	10%

GO-3.2 Has implementation of new control analytics improved across line-of-business decision-making?

A. No		16	47%	56	68%
B. Within individual lines of business	X	8	24%	15	18%
C. Across several lines of business		8	24%	9	11%
D. Across most or all lines of business		2	6%	2	2%

GO-3.3 Has grid operations planning transitioned from estimation to fact-based using grid data made available from smart grid deployment?

A. No		10	29%	40	49%
B. A little (<20% of planning decisions fact-based)	X	12	35%	24	29%
C. Moderately (25% - 75%)		8	24%	13	16%
D. To a great extent (75% - 90%)		2	6%	3	4%
E. Completely (>90%)		2	6%	2	2%

GO-3.4 Have smart meters become important grid management sensors within your network?

A. No	X	15	44%	49	60%

Answer					
B. In documented plan including committed schedule and budget		11	32%	19	23%
C. Moderately (<40% percent of grid is using meters as management sensors)		6	18%	10	12%
D. To a great extent (≥40%)		2	6%	4	5%

GO-3.5 Is grid data being used to support physical and cyber security through situational awareness and diagnostic activities?

Answer					
A. No	X	17	50%	47	57%
B. In documented plan including committed schedule and budget		3	9%	12	15%
C. Situational awareness and diagnostics deployed for one or more critical functions		10	29%	18	22%
D. Deployed for all critical functions		3	9%	4	5%
E. Deployed comprehensively across grid		1	3%	1	1%

GO-3.6 Is there automated decision-making within protection schemes (i.e., leveraging increased analytic capabilities and context)?

Answer					
A. No		11	32%	43	52%
B. In documented plan including committed schedule and budget		5	15%	12	15%
C. Analytics-based decision-support informs human operators	X	8	24%	12	15%
D. At least one analytics-based decision type is being automatically executed		7	21%	11	13%
E. Numerous analytics-based decision types are being automatically executed		3	9%	4	5%

Level 4: Optimizing

GO-4.1 Is operational data from smart grid deployments being used to optimize processes across the organization?

Answer					
A. No	X	18	53%	59	72%
B. A little (< 50% of impactable processes)		14	41%	21	26%
C. To a great extent (50% - 80% of impactable processes)		1	3%	1	1%
D. Completely (> 80% of impactable processes)		1	3%	1	1%

GO-4.2 Is your grid operational management based on near real-time data (dynamic grid management)?

Answer					
A. No	X	16	47%	42	51%

B. A little (<25% of operational decisions using near real-time data)		5	15%	14	17%
C. Moderately (25% - 75%)		9	26%	14	17%
D. To a great extent (76% - 90%)		3	9%	9	11%
E. Completely (>90%)		1	3%	3	4%

GO-4.3 Are your operational forecasts based upon data gathered through smart grid capabilities?

A. No	X	16	47%	48	59%
B. A little (<25% of operational decisions using near real-time data)		8	24%	18	22%
C. Moderately (25% - 75%)		7	21%	10	12%
D. To a great extent (76% - 90%)		2	6%	4	5%
E. Completely (>90%)		1	3%	2	2%

GO-4.4 Has grid operations information been made available across functions and lines of business (is there end-to-end observability)?

A. No	X	41	46%	75	54%
B. A little (< 50% of functions and lines of business have access to grid data)		37	41%	51	36%
C. To a great extent (50% - 80%)		8	9%	9	6%
D. Completely (> 80%)		4	4%	5	4%

GO-4.5 Is there automated decision-making within protection schemes based on wide area monitoring (beyond your operational boundaries)?

A. No	X	25	74%	68	83%
B. Wide area analytics-based decision-support informs human operators		6	18%	8	10%
C. At least one wide area analytics-based decision type is being automatically executed		3	9%	6	7%
D. Numerous wide area analytics-based decision types are being automatically executed		0	0%	0	0%

Level 5: Pioneering

GO-5.1 What percentage of your operational grid employs self-healing operations?

A. 0%		18	53%	51	62%
B. 1 - 25%	X	15	44%	26	32%
C. 26 - 50%		1	3%	2	2%
D. 51 - 75%		0	0%	2	2%

E. 76 - 100%		0	0%	1	1%

GO-5.2 Do you have analytics-based and automated decision-making in place system-wide (applying proven analytics-based control)?

A. No	X	71	79%	119	85%
B. A little (across <50% of your systems)		17	19%	19	14%
C. To a great extent (50% - 80%)		1	1%	1	1%
D. Completely (> 80%)		1	1%	1	1%

Domain: Work and Asset Management (WAM)

	eThekwini Municipality, Electricity Unit	SGMM Peer Community Data (≥250K Meters)		SGMM Community Data (All)	
		Count	Distribution	Count	Distribution

Work and Asset Management (WAM)

Level 1: Initiating

WAM-1.1 A. Do you have an approved functional-level business case for work and asset management enhancements via smart grid?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		23	26%	59	42%
B. In development	X	40	44%	52	37%
C. Approved		4	4%	4	3%
D. Approved and being executed		23	26%	25	18%

WAM-1.2 Are you evaluating potential uses of remote asset monitoring?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		12	13%	37	26%
B. In documented plan including committed schedule and budget	X	14	16%	20	14%
C. In progress		52	58%	71	51%
D. Completed		12	13%	12	9%

WAM-1.3 Are you evaluating or have you evaluated asset and workforce management equipment and systems for potential alignment to the smart grid vision?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		4	12%	22	27%
B. Yes, not aligned to smart grid vision	X	19	56%	39	48%
C. Yes, aligned to smart grid vision		6	18%	15	18%
D. Yes, and aligned to smart grid business case		5	15%	6	7%

Level 2: Enabling

WAM-2.1 Have you established an approach to track, inventory, and maintain event histories of assets using smart grid capabilities?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No	X	32	36%	65	46%
B. In documented plan including committed schedule and budget		14	16%	17	12%

C. In development		21	23%	31	22%
D. Being piloted		8	9%	11	8%
E. Completed		15	17%	16	11%

WAM-2.2 Have you developed an integrated view of GIS (Geographical Information Systems) for asset monitoring based upon location, status and interconnectivity (nodal)?

A. No		11	12%	31	22%
B. In documented plan including committed schedule and budget		12	13%	16	11%
C. In development	X	34	38%	56	40%
D. Being piloted		12	13%	12	9%
E. Completed		21	23%	25	18%

WAM-2.3 Has an organization-wide mobile workforce strategy been developed?

A. No	X	14	16%	44	31%
B. In documented plan including committed schedule and budget		7	8%	14	10%
C. In progress		46	51%	59	42%
D. Completed		23	26%	23	16%

Level 3: Integrating

WAM-3.1 What percentage of individual components in your cyber and physical systems has performance, trend analysis, and event audit data available?

A. 0%		6	18%	18	22%
B. 1 - 25%	X	16	47%	37	45%
C. 26 - 50%		5	15%	13	16%
D. 51 - 75%		5	15%	11	13%
E. 76 - 100%		2	6%	3	4%

WAM-3.2 For what percentage of key components have you implemented condition-based maintenance?

A. 0%		8	24%	28	34%
B. 1 - 25%	X	19	56%	35	43%
C. 26 - 50%		4	12%	10	12%
D. 51 - 75%		1	3%	6	7%
E. 76 - 100%		2	6%	3	4%

WAM-3.3 Have you integrated remote asset monitoring with asset management?

A. No		28	31%	70	50%
B. In documented plan including committed schedule and budget	X	12	13%	15	11%
C. In development		26	29%	28	20%
D. Completed to one or more asset classes		23	26%	26	19%
E. Completed (> 80% of asset classes)		1	1%	1	1%

WAM-3.4 Have you integrated remote asset monitoring capabilities with mobile workforce systems to automate work order creation?

A. No	X	43	48%	88	63%
B. In documented plan including committed schedule and budget		15	17%	19	14%
C. In development		18	20%	19	14%
D. Completed to one or more asset classes		13	14%	13	9%
E. Completed (> 80% of asset classes)		1	1%	1	1%

WAM-3.5 Have you implemented an integrated view of GIS and asset monitoring based upon location, status and interconnectivity?

A. No	X	25	28%	55	39%
B. In documented plan including committed schedule and budget		7	8%	16	11%
C. In development		35	39%	42	30%
D. Completed to one or more asset classes		15	17%	17	12%
E. Completed (> 80% of asset classes)		8	9%	10	7%

WAM-3.6 What percentage of your asset inventory is tracked using some level of automation from source to utilization (e.g., from supplier to installed location)?

A. 0%	X	15	44%	43	52%
B. 1 - 25%		9	26%	20	24%
C. 26 - 50%		2	6%	2	2%
D. 51 - 75%		5	15%	10	12%
E. 76 - 100%		3	9%	7	9%

WAM-3.7 Are you modeling asset investments for key components based upon smart grid data?

A. No		56	62%	100	71%

B. In documented plan including committed schedule and budget		9	10%	12	9%
C. In development		9	10%	11	8%
D. Completed to one or more components	X	13	14%	14	10%
E. Completed (> 80% of components)		3	3%	3	2%

Level 4: Optimizing

WAM-4.1 For what percentage of asset classes do you have a complete view (including location, interrelationships) based upon status (including security state), connectivity and proximity?

A. 0%	X	15	44%	47	57%
B. 1 - 25%		13	38%	21	26%
C. 26 - 50%		0	0%	3	4%
D. 51 - 75%		5	15%	8	10%
E. 76 - 100%		1	3%	3	4%

WAM-4.2 What percentage of your asset models are based upon real (both current and historical) performance and monitoring data?

A. 0%	X	15	44%	50	61%
B. 1 - 25%		16	47%	28	34%
C. 26 - 50%		3	9%	4	5%
D. 51 - 75%		0	0%	0	0%
E. 76 - 100%		0	0%	0	0%

WAM-4.3 Are you optimizing the performance and use of assets (from procurement through retirement) in consideration of the entire asset fleet and across asset categories?

A. No	X	18	53%	55	67%
B. 1 - 25% (of asset categories are optimized)		10	29%	17	21%
C. 26 - 50%		2	6%	3	4%
D. 51 - 75%		1	3%	1	1%
E. 76 - 100%		3	9%	6	7%

WAM-4.4 Do you have condition-based and predictive maintenance on key components?

A. No		9	26%	34	41%
B. 1 - 25% (of key components)	X	16	47%	33	40%
C. 26 - 50%		3	9%	6	7%
D. 51 - 75%		4	12%	6	7%
E. 76 - 100%		2	6%	3	4%

Level 5: Pioneering

WAM-5.1 Are you optimizing the use of assets between and across supply-chain participants?

A. No	X	27	79%	68	83%
B. For very few (<10% of asset classes or partners)		3	9%	8	10%
C. For some (10% - 49%)		3	9%	4	5%
D. For many (50% - 80%)		1	3%	1	1%
E. Yes (> 80%)		0	0%	1	1%

WAM-5.2 Are your assets leveraged to maximize utilization, including just-in-time asset retirement, based on smart grid data and systems?

A. No	X	27	79%	72	88%
B. For very few (<10% of assets)		5	15%	8	10%
C. For some (10% - 49%)		2	6%	2	2%
D. For many (50% - 80%)		0	0%	0	0%
E. Yes (> 80%)		0	0%	0	0%

Domain: Technology (Tech)

eThekwini Municipality, Electricity Unit	SGMM Peer Community Data (≥250K Meters)		SGMM Community Data (All)	
	Count	Distribution	Count	Distribution

Technology (TECH)

Level 1: Initiating

TECH-1.1 Do you have an enterprise IT architecture?

Answer	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		4	4%	14	10%
B. Evaluating benefits of candidate IT architectures		6	7%	9	6%
C. Enterprise IT architecture is under development	X	28	31%	37	26%
D. Yes		52	58%	80	57%

TECH-1.2 Have you evaluated your existing or proposed enterprise IT architecture for the quality attributes that would support smart grid applications?

Answer	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		1	3%	20	24%
B. In planning		8	24%	15	18%
C. Informal evaluations	X	14	41%	28	34%
D. Formal evaluations		11	32%	19	23%

TECH-1.3 Do you have a change control process (e.g., configuration management, patch updates) for applications and IT infrastructure?

Answer	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		0	0%	12	15%
B. Informal process		2	6%	13	16%
C. Formal process deployed for at least one class of applications or one IT infrastructure element (e.g., servers, routers)		5	15%	18	22%
D. Formal process deployed for numerous classes and/or elements	X	16	47%	23	28%
E. Formal process deployed for all classes and elements		11	32%	16	20%

TECH-1.4 Have you identified where technology can improve the performance of functional departments (e.g., reduce cost, improve workflow, simplify, automate, reduce risk, improve flexibility/adaptability)?

A. No
B. Partial
C. Complete
D. Previously in place

	1	3%	5	6%
X	20	59%	58	71%
	2	6%	4	5%
	11	32%	15	18%

TECH-1.5 Do you have a process to evaluate and select technologies in alignment with your smart grid vision and/or strategy?

A. No
B. Indirectly (not specific for smart grid)
C. Informal processes used
D. Yes, formal process in place for at least one function and/or line of business
E. Yes, formal process in place for most or all functions and/or lines of business

	1	3%	12	15%
X	16	47%	33	40%
	5	15%	14	17%
	4	12%	12	15%
	8	24%	11	13%

Level 2: Enabling

TECH-2.1 Do you align tactical IT investments to your enterprise IT architecture?

A. No
B. Within a function and/or line of business
C. Across multiple functions and/or lines of business
D. Across all functions and/or lines of business

	10	11%	26	19%
X	15	17%	27	19%
	43	48%	58	41%
	22	24%	29	21%

TECH-2.2 Are changes to your enterprise IT architecture to enable smart grid being deployed?

A. No
B. In progress
C. Within a function and/or line of business
D. Across multiple functions and/or lines of business
E. Across all functions and/or lines of business

	4	12%	31	38%
X	12	35%	21	26%
	4	12%	6	7%
	11	32%	19	23%
	3	9%	5	6%

TECH-2.3 Have you selected standards that support your smart grid strategy within your enterprise IT architecture?

A. No
B. Being evaluated and or developed
C. Key standards selected
D. Most or all needed standards have been selected

	9	26%	38	46%
X	9	26%	22	27%
	9	26%	14	17%
	7	21%	8	10%

TECH-2.4 Does your organization adhere to a common technology evaluation and selection process for all smart grid activities, including vendor and external source selection?

A.	No		6	18%	26	32%
B.	Informal processes used		5	15%	19	23%
C.	Formal process in place for at least one function/line of business	X	8	24%	15	18%
D.	Formal process in place for most or all functions/lines of business		15	44%	22	27%

TECH-2.5 Do you have a data communications strategy for your grid?

A.	No	X	8	24%	31	38%
B.	In documented plan including committed schedule and budget		2	6%	5	6%
C.	Under development		13	38%	27	33%
D.	Complete and approved		2	6%	4	5%
E.	Being executed		9	26%	15	18%

TECH-2.6 Are pilots underway for business unit applications based on connectivity to intelligent electronic devices (IED) (e.g., remote processors)?

A.	No, IED connectivity not yet in place		3	9%	22	27%
B.	No business unit pilots are planned		0	0%	6	7%
C.	In documented plan including committed schedule and budget		4	12%	5	6%
D.	Pilots underway	X	16	47%	31	38%
E.	Pilots complete		11	32%	18	22%

TECH-2.7 What percentage of smart grid initiatives have information security considerations built in from the outset?

A.	0%		3	9%	19	23%
B.	1 - 25%		4	12%	9	11%
C.	26 - 50%		4	12%	7	9%
D.	51 - 75%		3	9%	9	11%
E.	76 - 100%	X	20	59%	38	46%

Level 3: Integrating

TECH-3.1 Are smart grid-impacted business processes aligned with your enterprise IT architecture across LOBs?

A. No		29	32%	59	42%
B. In development		27	30%	36	26%
C. A little (< 30% of impacted processes)		14	16%	19	14%
D. To a great extent (30% - 70%)	X	13	14%	18	13%
E. Completely (> 70%)		7	8%	8	6%

TECH-3.2 What percentage of your systems adhere to your enterprise IT architectural framework for smart grid?

A. 0%		6	18%	29	35%
B. 1 - 25%	X	12	35%	27	33%
C. 26 - 50%		8	24%	10	12%
D. 51 - 75%		4	12%	8	10%
E. 76 - 100%		4	12%	8	10%

TECH-3.3 Have you implemented smart grid-specific technology to improve cross-LOB performance (e.g., peak demand management, fault detection, integrated VVO)?

A. No		7	21%	36	44%
B. Only as pilots or demonstration projects	X	12	35%	22	27%
C. Within one or more functions and/or lines of business		10	29%	18	22%
D. Integrated across multiple functions and/or lines of business		4	12%	5	6%
E. Integrated across all functions and/or lines of business		1	3%	1	1%

TECH-3.4 Do you have distributed intelligence and analytical capabilities that are enabled through smart grid technologies?

A. No		32	36%	65	46%
B. In development	X	30	33%	38	27%
C. Within one or more functions and/or lines of business		22	24%	30	21%
D. Integrated across multiple functions and/or lines of business		5	6%	6	4%
E. Integrated across all functions and/or lines of business		1	1%	1	1%

TECH-3.5 Do you have an advanced sensor plan (e.g., for situational awareness, for near real-time control, using phasor measurement units or other sophisticated sensors)?

A. No		33	37%	63	45%
B. In development		31	34%	44	31%
C. Within one or more functions and/or lines of business	X	18	20%	24	17%
D. Supports across multiple functions and/or lines of business		5	6%	6	4%
E. Supports all functions and/or lines of business		3	3%	3	2%

TECH-3.6 Do you have a detailed data communications strategy and corresponding tactics in place?

A. No		15	17%	43	31%
B. In development	X	39	43%	47	34%
C. Within functions and/or lines of business		8	9%	15	11%
D. Across multiple functions and/or lines of business		14	16%	21	15%
E. Across all functions and/or lines of business		14	16%	14	10%

Level 4: Optimizing

TECH-4.1 Do you have end-to-end data flow from customer to generation (where permitted by security, privacy, and other requirements)?

A. No		59	66%	103	74%
B. In development	X	14	16%	16	11%
C. A little (connecting <50% of customers and sources)		12	13%	14	10%
D. To a great extent (50% - 80%)		3	3%	4	3%
E. Yes (> 80%)		2	2%	3	2%

TECH-4.2 What percentage of your business processes are optimized by leveraging your enterprise IT architecture?

A. 0%		9	26%	28	34%
B. 1 - 25% (of impactable processes)	X	14	41%	33	40%
C. 26 - 50%		5	15%	10	12%
D. 51 - 75%		4	12%	9	11%
E. 76 - 100%		2	6%	2	2%

TECH-4.3 Do your systems have sufficient wide-area situational awareness to enable real-time monitoring/control/mitigation in response to complex events (e.g., natural disasters, severe weather, extreme demand fluctuations, etc.)?

A. No	X	16	47%	38	46%
B. In development		6	18%	15	18%
C. 1 - 25% (of applicable systems)		7	21%	15	18%
D. 26 - 50%		0	0%	5	6%
E. 51 - 75%		2	6%	4	5%
F. 76 - 100%		3	9%	5	6%

TECH-4.4 Do you use predictive modeling and/or near real-time simulation to optimize support processes (e.g., for maintenance, power management, call center, decision support)?

A. No	X	14	41%	47	57%
B. In development		10	29%	14	17%
C. 1 - 25% (of applicable systems)		7	21%	15	18%
D. 26 - 50%		0	0%	2	2%
E. 51 - 75%		3	9%	4	5%
F. 76 - 100%		0	0%	0	0%

TECH-4.5 Is your organization's performance being improved by using sophisticated systems that are informed by smart grid data (e.g., business intelligence or knowledge management systems)?

A. No	X	14	41%	48	59%
B. In development		11	32%	19	23%
C. Somewhat		8	24%	13	16%
D. To a great extent		1	3%	2	2%

TECH-4.6 Do your security strategy and tactics continually evolve based on changes in the operational environment and lessons learned?

A. No		4	12%	18	22%
B. Only in response to changes in standards or regulatory requirements		5	15%	15	18%
C. Yes, in an ad hoc manner	X	13	38%	25	30%
D. Yes, as part of a continuous process		12	35%	24	29%

Level 5: Pioneering

TECH-5.1 Have you implemented autonomic computing using machine learning?

A. No	X	79	88%	125	89%

B. In development		7	8%	9	6%
C. Limited deployment		4	4%	6	4%
D. Extensive deployment		0	0%	0	0%

TECH-5.2 Does your information systems automatically identify, mitigate, and recover from cyber incidents?

A. No	X	21	62%	57	70%
B. In development		6	18%	12	15%
C. Limited deployment		3	9%	8	10%
D. Extensive deployment		4	12%	5	6%
E. Complete deployment, the systems automatically inform relevant stakeholders		0	0%	0	0%

Domain: Customer (CUST)

	eThekwini Municipality, Electricity Unit	SGMM Peer Community Data (≥250K Meters)		SGMM Community Data (All)	
		Count	Distribution	Count	Distribution

Customer (CUST)

Level 1: Initiating

CUST-1.1 Are you conducting research on how to use smart grid technologies to enhance your customers' experience, benefits, and participation?

Answer	eThekwini Municipality, Electricity Unit	SGMM Peer Count	SGMM Peer Distribution	SGMM All Count	SGMM All Distribution
A. No		3	9%	16	20%
B. Indirectly (not as part of your smart grid initiatives, but providing smart grid insights)	X	13	38%	33	40%
C. Directly as needed		10	29%	16	20%
D. Continuously as part of your normal process		8	24%	17	21%

CUST-1.2 Are you investigating the security and privacy implications of the new technologies and business functions that enable customer participation in the smart grid?

Answer	eThekwini Municipality, Electricity Unit	SGMM Peer Count	SGMM Peer Distribution	SGMM All Count	SGMM All Distribution
A. No		5	15%	20	24%
B. Indirectly (not as part of your smart grid initiatives, but providing smart grid insights)		10	29%	29	35%
C. Directly as needed	X	8	24%	12	15%
D. Continuously as part of your normal process		11	32%	21	26%

CUST-1.3 Are you communicating and explaining your vision of the future grid to your customers (e.g., by explaining smart grid benefits and describing potential use case scenarios)?

Answer	eThekwini Municipality, Electricity Unit	SGMM Peer Count	SGMM Peer Distribution	SGMM All Count	SGMM All Distribution
A. No	X	13	38%	36	44%
B. Informal, no structured communications		6	18%	21	26%
C. Indirect through media or other channels		4	12%	8	10%
D. Direct with customers		11	32%	17	21%

CUST-1.4 Are you consulting with public utility commissions and/or other government organizations regarding the impact on customers of your smart grid strategies and anticipated implementation schedule?

Answer	eThekwini Municipality, Electricity Unit	SGMM Peer Count	SGMM Peer Distribution	SGMM All Count	SGMM All Distribution
A. No	X	5	15%	24	29%
B. On a limited basis (collaboration is infrequent and not part of normal business processes)		17	50%	40	49%

C. Extensively (collaborations are frequent and are a part of normal business processes)		12	35%	18	22%

Level 2: Enabling

CUST-2.1 Have you piloted Advanced Metering Infrastructure (AMI) and /or Automated Meter Reading (AMR) to residential customers?

A. No	X	4	12%	17	21%
B. In documented plan including committed schedule and budget		3	9%	9	11%
C. Piloting		10	29%	17	21%
D. Deployed		17	50%	39	48%

CUST-2.2 Do you collect residential customer usage data more frequently than monthly for use in operational analytics and planning?

A. No	X	15	44%	51	62%
B. In documented plan including committed schedule and budget		4	12%	6	7%
C. In development		0	0%	4	5%
D. Partially deployed to customers (<40%)		11	32%	14	17%
E. To a great extent (>=40%)		4	12%	7	9%

CUST-2.3 Are you modeling reliability of grid equipment?

A. No		13	38%	41	50%
B. In documented plan including committed schedule and budget		2	6%	7	9%
C. In development		1	3%	7	9%
D. Yes, for at least one asset class	X	5	15%	10	12%
E. Yes, for multiple asset classes		13	38%	17	21%

CUST-2.4 Have you piloted remote disconnect/connect technologies for residential customers?

A. No	X	12	35%	43	52%
B. In documented plan including committed schedule and budget		1	3%	5	6%
C. Piloting		10	29%	16	20%
D. Deployed		11	32%	18	22%

CUST-2.5 Are you assessing the impact on customers of new services and delivery processes such as Home Area Networks (HAN), smart meter installs, dynamic pricing, and/or turning power on/off remotely?

A. No		23	26%	57	41%
B. In documented plan with committed schedule and budget	X	22	24%	26	19%
C. In process		44	49%	56	40%
D. Completed		1	1%	1	1%

CUST-2.6 What percentage of smart grid-related pilots and Requests for Proposals (RFPs) specify security and privacy requirements for customer protection?

A. 0%		7	21%	35	43%
B. 1 - 25%		6	18%	11	13%
C. 26 - 50%	X	2	6%	2	2%
D. 51 - 75%		1	3%	1	1%
E. 76 - 100%		18	53%	33	40%

Level 3: Integrating

CUST-3.1 Do you have residential customer segmentation that can enable more tailored customer programs?

A. No		9	26%	38	46%
B. Being evaluated	X	6	18%	13	16%
C. Segmented (ability to segment based upon a single criterion)		12	35%	23	28%
D. Highly segmented (ability to segment based upon combinations of criteria)		7	21%	8	10%

CUST-3.2 What percentage of residential customer meters has two-way communication capabilities (e.g., an advanced metering infrastructure)?

A. 0%	X	14	41%	49	60%
B. 1 - 25%		16	47%	26	32%
C. 26 - 50%		0	0%	0	0%
D. 51 - 75%		1	3%	1	1%
E. 76 - 100%		3	9%	6	7%

CUST-3.3 For what percentage of residential customers have you enabled remote connect/disconnect capability?

A. 0%	X	20	59%	59	72%

B. 1 - 25%		10	29%	17	21%
C. 26 - 50%		2	6%	2	2%
D. 51 - 75%		0	0%	0	0%
E. 76 - 100%		2	6%	4	5%

CUST-3.4 For what percentage of residential customers have you enabled demand response or remote load control?

A. 0%	X	25	74%	69	84%
B. 1 - 25%		6	18%	9	11%
C. 26 - 50%		0	0%	0	0%
D. 51 - 75%		1	3%	1	1%
E. 76 - 100%		2	6%	3	4%

CUST-3.5 What percentage of substations is equipped with automated outage detection?

A. 0%	X	5	15%	19	23%
B. 1 - 25%		7	21%	9	11%
C. 26 - 50%		2	6%	5	6%
D. 51 - 75%		3	9%	7	9%
E. 76 - 100%		17	50%	42	51%

CUST-3.6 What percentage of residential customers has on-demand access to daily (or more frequent) usage data?

A. 0%	X	22	65%	66	80%
B. 1 - 25%		8	24%	11	13%
C. 26 - 50%		0	0%	0	0%
D. 51 - 75%		0	0%	0	0%
E. 76 - 100%		4	12%	5	6%

CUST-3.7 Have you implemented a common customer experience (e.g., look and feel, consistency of message, available information) across at least two residential customer interface channels?

A. No	X	4	12%	33	40%
B. In documented plan		0	0%	4	5%
C. In progress		7	21%	11	13%
D. Completed for at least two channels (e.g., web, voice response, hand-held)		15	44%	24	29%
E. Completed across multiple channels (e.g., web, voice response, hand-held)		8	24%	10	12%

CUST-3.8 Do you provide customer education on how to use smart grid services to curtail peak usage?

A. No	X	21	62%	62	76%
B. Yes, available through passive channels (e.g. web)		5	15%	7	9%
C. Yes, active, indirect through media or other broadcast channels		3	9%	6	7%
D. Yes, active, direct and targeted to individual consumers		5	15%	7	9%

CUST-3.9 What percentage of customer products and services has built-in security and privacy controls that meet relevant industry and government standards?

A. 0%	X	12	35%	38	46%
B. 1 - 25%		6	18%	10	12%
C. 26 - 50%		1	3%	1	1%
D. 51 - 75%		2	6%	2	2%
E. 76 - 100%		13	38%	31	38%

Level 4: Optimizing

CUST-4.1 Do you provide support to customers to help them analyze and compare their actual usage against all available pricing programs?

A. No, or in development		13	38%	40	49%
B. Limited (<50% of customers or programs)	X	16	47%	29	35%
C. Extensive (50% - 90%)		1	3%	1	1%
D. Yes, for essentially all customers and programs (>90%)		4	12%	12	15%

CUST-4.2 What percentage of circuits is equipped with automatic outage detection and proactive notification?

A. 0%	X	21	62%	53	65%
B. 1 - 25%		7	21%	10	12%
C. 26 - 50%		1	3%	3	4%
D. 51 - 75%		0	0%	2	2%
E. 76 - 100%		5	15%	14	17%

CUST-4.3 What percentage of customers has on-demand access to near real-time (up to the minute) usage data?

A. 0%	X	23	68%	60	73%
B. 1 - 25%		9	26%	19	23%
C. 26 - 50%		0	0%	0	0%
D. 51 - 75%		0	0%	0	0%
E. 76 - 100%		2	6%	3	4%

CUST-4.4 What percentage of customers participate in demand response or remote load control programs?

A. 0%		20	59%	59	72%
B. 1 - 25%	X	13	38%	21	26%
C. 26 - 50%		1	3%	1	1%
D. 51 - 75%		0	0%	1	1%
E. 76 - 100%		0	0%	0	0%

CUST-4.5 What percentage of residential customers are provided with the capability for automated response to pricing signals for major energy consumption devices in their premise?

A. 0%	X	29	85%	76	93%
B. 1 - 25%		4	12%	5	6%
C. 26 - 50%		0	0%	0	0%
D. 51 - 75%		0	0%	0	0%
E. 76 - 100%		1	3%	1	1%

CUST-4.6 For what percentage of customers are in-home net billing programs available (i.e., credit/payment for solar panels, wind, electric vehicle battery to grid)?

A. 0%	X	17	50%	49	60%
B. 1 - 25%		8	24%	17	21%
C. 26 - 50%		0	0%	0	0%
D. 51 - 75%		1	3%	1	1%
E. 76 - 100%		8	24%	15	18%

CUST-4.7 Have you integrated a common experience across all residential customer interfaces for all services provided (e.g., leveraging common data sources)?

A. No	X	11	32%	44	54%
B. In progress		9	26%	15	18%
C. Completed for at least two channels		6	18%	13	16%
D. Completed across multiple channels		3	9%	5	6%
E. Across all channels		5	15%	5	6%

Level 5: Pioneering

CUST-5.1 What percentage of customers can manage their end-to-end energy supply and usage levels (energy source and mix)?

A. 0%		26	76%	72	88%
B. 1 - 25%	X	5	15%	7	9%
C. 26 - 50%		0	0%	0	0%
D. 51 - 75%		0	0%	0	0%
E. 76 - 100%		3	9%	3	4%

CUST-5.2 What percentage of customers (including residential) have automatic outage detection at the premise or device level?

A. 0%	X	26	76%	69	84%
B. 1 - 25%		6	18%	9	11%
C. 26 - 50%		0	0%	0	0%
D. 51 - 75%		0	0%	1	1%
E. 76 - 100%		2	6%	3	4%

CUST-5.3 What percentage of customers is supported by plug-and-play customer-based generation (including necessary support infrastructure such as net billing, control, etc.)?

A. 0%	X	29	85%	72	88%
B. 1 - 25%		3	9%	6	7%
C. 26 - 50%		1	3%	1	1%
D. 51 - 75%		0	0%	0	0%
E. 76 - 100%		1	3%	3	4%

CUST-5.4 Can you provide compelling evidence of assurance of the security and privacy of customer data stored, transmitted or processed on the grid?

A. No	X	19	56%	54	66%
B. Self-generated evidence (e.g., design reviews, code reviews)		7	21%	16	20%
C. Externally generated evidence (e.g., third-party certifications, third-party reviews)		1	3%	1	1%
D. Both		7	21%	11	13%

CUST-5.5 Do you play a leadership role in industry-wide information sharing and standards development efforts for smart grid?

A. No		24	71%	68	83%
B. For the protection of customer security and privacy		2	6%	2	2%

C. For the promotion of customer choice and control

D. Both

X	2	6%	2	2%
	6	18%	10	12%

Domain: Value Chain Integration (VCI)

	eThekwini Municipality, Electricity Unit	SGMM Peer Community Data (≥250K Meters)		SGMM Community Data (All)	
		Count	Distribution	Count	Distribution

Value Chain Integration (VCI)

Level 1: Initiating

VCI-1.1 Have you identified the assets and programs needed to facilitate load management?

	eThekwini	Count	Distribution	Count	Distribution
A. No		13	38%	41	50%
B. In documented plan including committed schedule and budget		4	12%	10	12%
C. Evaluation and identification underway	X	11	32%	22	27%
D. Identification completed		6	18%	9	11%

VCI-1.2 Have you identified distributed generation sources and the capabilities needed to support them?

	eThekwini	Count	Distribution	Count	Distribution
A. No		4	12%	28	34%
B. In documented plan including committed schedule and budget	X	6	18%	12	15%
C. Evaluation and identification underway		14	41%	26	32%
D. Identification completed		10	29%	16	20%

VCI-1.3 Have you identified energy storage options and the capabilities needed to support them?

	eThekwini	Count	Distribution	Count	Distribution
A. No	X	19	56%	54	66%
B. In documented plan including committed schedule and budget		1	3%	4	5%
C. Evaluation and identification underway		8	24%	16	20%
D. Identification completed		6	18%	8	10%

VCI-1.4 Do you have a strategy for developing, enabling, and managing a diverse resource portfolio (e.g., integration of new resources such as DR, DG)?

	eThekwini	Count	Distribution	Count	Distribution
A. No		29	32%	59	42%
B. In process of creating strategy	X	41	46%	53	38%
C. Complete		4	4%	4	3%

D. Being executed to		16	18%	24	17%

VCI-1.5 Have you identified security requirements to enable interaction with an expanded portfolio of value chain partners?

A. No		18	53%	52	63%
B. In documented plan including committed schedule and budget		2	6%	7	9%
C. Evaluation and identification underway	X	6	18%	10	12%
D. Identification completed		8	24%	13	16%

Level 2: Enabling

VCI-2.1 Are you providing support for home energy management systems (e.g., via customer portals or in-home displays)?

A. No		41	46%	78	56%
B. In documented plan including committed schedule and budget	X	15	17%	19	14%
C. In progress		21	23%	26	19%
D. Moderately (<40% of customers)		9	10%	12	9%
E. To a great extent (≥40%)		4	4%	5	4%

VCI-2.2 Have you redefined the value chain based upon smart grid capabilities (including DG, micro-generation, energy storage, and other new customers and suppliers)?

A. No	X	24	71%	65	79%
B. In documented plan including committed schedule and budget		2	6%	4	5%
C. In progress		6	18%	10	12%
D. Complete		2	6%	3	4%

VCI-2.3 Are you conducting pilots to support a diverse resource portfolio (e.g, distributed generation, demand-side management, demand response, storage)?

A. No	X	8	24%	41	50%
B. In documented plan including committed schedule and budget		3	9%	5	6%
C. Piloting underway		12	35%	24	29%
D. Piloting activities completed		3	9%	3	4%
E. Piloting completed and deployment in progress		8	24%	9	11%

VCI-2.4 Are you piloting secure interaction with an expanded portfolio of value chain partners?

A. No	X	21	62%	60	73%
B. In documented plan including committed schedule and budget		1	3%	4	5%
C. Piloting underway		4	12%	7	9%
D. Piloting activities completed		1	3%	2	2%
E. Piloting completed and deployment in progress		7	21%	9	11%

Level 3: Integrating

VCI-3.1 Do you have an integrated resource plan in place that includes new targeted resources and technologies (e.g., Volt/Volt-Ampere Reactive (VAR) management systems, demand response, distributed generation)?

A. No	X	33	37%	65	46%
B. In development		23	26%	31	22%
C. Partly in place (supporting at least one resource)		19	21%	29	21%
D. Mostly in place (supporting multiple resources)		10	11%	10	7%
E. Completely in place (supporting all available resources)		5	6%	5	4%

VCI-3.2 Have you enabled customer (including commercial, industrial, and residential) premise energy management solutions with market and usage information?

A. No		44	49%	83	59%
B. In development		18	20%	21	15%
C. A little (< 10% of all customers)	X	23	26%	31	22%
D. To a great extent (10% - 70%)		3	3%	3	2%
E. Completely (≥70%)		2	2%	2	1%

VCI-3.3 Additional resources (e.g., PHVs, storage, DR) are being enabled or deployed to provide substitutes for market products to support reliability or other objectives?

A. No	X	20	59%	61	74%
B. Resources identified but not enabled		4	12%	7	9%
C. At least one new resource enabled		8	24%	11	13%
D. Numerous new resources enabled		1	3%	2	2%
E. Continuous identification and enablement process in place		1	3%	1	1%

VCI-3.4 Have you deployed security management and monitoring processes to protect the interactions with your expanded portfolio of value chain partners?

A. No	X	22	65%	59	72%
B. In development		2	6%	6	7%
C. Security processes are in place within your organization		2	6%	8	10%
D. Collaborative security processes are in place with at least one value chain partner		5	15%	5	6%
E. Collaborative security processes are in place across your value chain		3	9%	4	5%

Level 4: Optimizing

VCI-4.1 Are your energy resources (including resources such as Volt/Var, DR, DG) dispatchable and tradeable?

A. No	X	50	56%	89	64%
B. In development		12	13%	15	11%
C. For one resource		11	12%	15	11%
D. For two or more resources		11	12%	15	11%
E. For all available resources		6	7%	6	4%

VCI-4.2 Have you implemented portfolio optimization models that encompass available resources and real-time markets (e.g., to enable response to dynamic market/supply conditions)?

A. No	X	58	64%	98	70%
B. In development		8	9%	13	9%
C. For at least two resources		8	9%	9	6%
D. For numerous resources		9	10%	11	8%
E. For all available resources		7	8%	9	6%

VCI-4.3 To what percentage of residential customers do you offer secure two-way communication via Home Area Networks (HAN)?

A. None	X	22	65%	69	84%
B. In development		6	18%	6	7%
C. 1 - 25%		4	12%	4	5%
D. 26 - 50%		0	0%	0	0%
E. 51 - 75%		1	3%	1	1%
F. 76 - 100%		1	3%	2	2%

VCI-4.4 For what percentage of residential customers do you have visibility and control of large-demand appliances (e.g., air conditioners, water heaters)?

A. None	X	22	65%	68	83%
B. In development		6	18%	7	9%
C. 1 - 25%		6	18%	6	7%
D. 26 - 50%		0	0%	0	0%
E. 51 - 75%		0	0%	1	1%
F. 76 - 100%		0	0%	0	0%

Level 5: Pioneering

VCI-5.1 Have you automated the optimization of energy assets across the full value chain?

A. No	X	29	85%	73	89%
B. In development		3	9%	5	6%
C. Somewhat (<50% of energy assets)		1	3%	3	4%
D. Substantially (50% - 80%)		1	3%	1	1%
E. Extensively (> 80%)		0	0%	0	0%

VCI-5.2 Are your resources adequately dispatchable and controllable so that you can take advantage of granular market options (e.g., locational marginal pricing)?

A. No	X	29	85%	69	84%
B. In development		3	9%	6	7%
C. Somewhat (<50% of energy assets)		0	0%	1	1%
D. Substantially (50% - 80%)		0	0%	1	1%
E. Extensively (> 80%)		2	6%	5	6%

VCI-5.3 Do your automated control and resource optimization schemes consider and support regional and/or national grid optimization?

A. No		20	59%	57	70%
B. In development		6	18%	9	11%
C. To a limited extent	X	7	21%	12	15%
D. Yes, to a significant extent		1	3%	4	5%

Domain: Societal and Environment (SE)

	eThekwini Municipality, Electricity Unit	SGMM Peer Community Data (≥250K Meters)		SGMM Community Data (All)	
		Count	Distribution	Count	Distribution

Societal and Environmental (SE)

Level 1: Initiating

SE-1.1 Does your smart grid strategy or vision address your organization's role in societal and environmental issues?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No	X	7	21%	33	40%
B. Role acknowledged		16	47%	32	39%
C. Role acknowledged and goals established		5	15%	7	9%
D. Role acknowledged, goals established, and strategy detailed		6	18%	10	12%

SE-1.2 Have you publicly promoted the environmental benefits of your smart grid vision or strategy?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No	X	13	38%	46	56%
B. Informally, no structured communications		9	26%	18	22%
C. Indirectly through media or other channels		5	15%	6	7%
D. Directly with customers		0	0%	0	0%
E. Both directly and indirectly		7	21%	12	15%

SE-1.3 Is your compliance record with environmental regulations made available for public inspection?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		5	15%	14	17%
B. Available upon specific request	X	9	26%	38	46%
C. Available through multiple channels on demand		6	18%	10	12%
D. Available and actively publicized		14	41%	20	24%

SE-1.4 Does your smart grid vision or strategy specify your role in protecting the nation's critical infrastructure?

	eThekwini	Peer Count	Peer Distribution	All Count	All Distribution
A. No		8	24%	39	48%
B. Role acknowledged		13	38%	25	30%
C. Role acknowledged and goals established	X	7	21%	10	12%

D. Role acknowledged, goals established, and strategy detailed		6	18%	8	10%

Level 2: Enabling

SE-2.1 Do your smart grid strategies and work plans address societal and environmental issues (cost increases, global warming, pollution, hazardous materials, spill control, "not in my backyard," and other public concerns)?

A. No		9	26%	41	50%
B. In development	X	12	35%	20	24%
C. Moderately (smart grid work plans and strategies address a few issues)		10	29%	17	21%
D. Extensively (address a broad range of issues)		3	9%	4	5%

SE-2.2 Have you established energy efficiency programs for customers?

A. No		2	6%	16	20%
B. In documented plan including committed schedule and budget		0	0%	10	12%
C. Being piloted		2	6%	4	5%
D. For at least one customer category or segment	X	15	44%	18	22%
E. For all customers		15	44%	34	41%

SE-2.3 Does your organization consider a "triple bottom line" view when making decisions (considering social, environmental, and financial performance measures)?

A. No		6	18%	24	29%
B. Under consideration		1	3%	11	13%
C. In at least one function and/or line of business	X	14	41%	27	33%
D. Across all functions and/or lines of business		13	38%	20	24%

SE-2.4 Have you implemented environmental proof-of-concept projects (e.g., solar or wind generation) to demonstrate smart grid benefits to the public and the environment?

A. No		8	24%	33	40%
B. In documented plan including committed schedule and budget		2	6%	4	5%
C. In progress	X	13	38%	26	32%
D. Complete		11	32%	19	23%

SE-2.5 Are you making increasingly granular and more frequent consumption information available to customers (including residential)?

A. No		7	21%	26	32%
B. Monthly consumption data available	X	15	44%	38	46%
C. More frequent than monthly consumption data available		4	12%	5	6%
D. Daily or better consumption data available		8	24%	13	16%

Level 3: Integrating

SE-3.1 Are your societal and environmental programs within your smart grid strategy measurably effective?

A. No	X	17	50%	52	63%
B. Only informal performance measurement		6	18%	17	21%
C. Formal performance measurement being implemented		6	18%	8	10%
D. Formal performance measures, meeting targeted performance		3	9%	3	4%
E. Formal performance measures, exceeding targeted performance		2	6%	2	2%

SE-3.2 Does your organization make available to customers (including commercial, industrial, and residential) segmented and tailored information that includes environmental and societal benefits and costs?

A. No		17	50%	56	68%
B. In development	X	6	18%	9	11%
C. A little (< 30% of all customers)		7	21%	13	16%
D. Moderately (30% - 80%)		1	3%	1	1%
E. To a great extent (≥80%)		3	9%	3	4%

SE-3.3 Has your organization established programs to encourage off-peak usage by customers?

A. No		7	21%	35	43%
B. In documented plan		4	12%	8	10%
C. A little (available to <30% of all customers)		14	41%	26	32%
D. Moderately (30% - 80%)	X	4	12%	7	9%
E. To a great extent (≥80%)		5	15%	6	7%

SE-3.4 Does your organization regularly report on the sustainability and the societal and environmental impacts of its smart grid programs and technologies?

A. No	X	22	65%	63	77%
B. Available upon specific request		7	21%	11	13%
C. Available through multiple channels on demand		2	6%	2	2%
D. Available and actively publicized		3	9%	6	7%

Level 4: Optimizing

SE-4.1 Does your organization collaborate with outside stakeholders to address societal and environmental issues?

A. No		8	9%	27	19%
B. Key outside stakeholders for key issues		48	53%	73	52%
C. All stakeholders for key issues	X	23	26%	28	20%
D. All stakeholders for all issues		11	12%	12	9%

SE-4.2 Does your organization maintain a public environmental and societal scorecard?

A. No	X	16	47%	47	57%
B. On a limited basis		9	26%	19	23%
C. Extensively		5	15%	11	13%
D. Completely		4	12%	5	6%

SE-4.3 Have you implemented smart grid programs (e.g., demand response programs, dynamic pricing signals, and managed control of devices) to shave peak demand?

A. No		14	41%	50	61%
B. In development		4	12%	9	11%
C. On a limited basis (i.e., available to a limited set of customers or with limited options)	X	14	41%	21	26%
D. Extensively (i.e., available to >90% of customers with multiple options)		2	6%	2	2%

SE-4.4 For what percentage of customers (including commercial, industrial, and residential) can you actively manage end-user usage and devices and therefore consumption, where appropriate, through your network?

A. 0%	X	23	68%	63	77%
B. 1 - 25%		10	29%	17	21%
C. 26 - 50%		0	0%	1	1%
D. 51 - 75%		0	0%	0	0%

E. 76 - 100%		1	3%	1	1%

SE-4.5 Does your organization fulfil its critical infrastructure assurance goals for resilience and contribute to those of the region and the nation?

A. There are no explicit critical infrastructure assurance goals		10	29%	34	41%
B. Some explicit critical infrastructure assurance goals are being achieved		6	18%	19	23%
C. All explicit critical infrastructure assurance goals are being adequately fulfilled		7	21%	12	15%
D. Explicit critical infrastructure assurance goals are tested and proven to be adequately fulfilled	X	5	15%	8	10%
E. Compelling evidence exists of comprehensive goal fulfilment and of contributions to the region and the nation as a whole		6	18%	9	11%

Level 5: Pioneering

SE-5.1 Do your organization's triple-bottom-line goals align with local, regional, and national objectives?

A. No		6	18%	29	35%
B. Limited alignment		7	21%	25	30%
C. Aligned	X	17	50%	24	29%
D. Aligned and organization meets or exceeds		4	12%	4	5%

SE-5.2 What percentage of customers are enabled to control their energy-based environmental footprint through automatic optimization of their end-to-end energy supply and usage level (energy source and mix) based on customer-selected preferences?

A. 0%	X	29	85%	72	88%
B. 1 - 25%		3	9%	7	9%
C. 26 - 50%		0	0%	1	1%
D. 51 - 75%		0	0%	0	0%
E. 76 - 100%		2	6%	2	2%

SE-5.3 Is your organization a leader in developing and promoting industry-wide resilience best practices and/or technologies for protection of the national critical infrastructure?

A. No		5	15%	30	37%
B. No, but members of our organization participate in relevant industry and/or government forums		11	32%	31	38%
C. Yes, members of our organization are leaders in relevant industry and/or government	X	16	47%	18	22%

forums					
D. Yes, and we pioneer and promote best practices, methods, and/or technologies for smart grid resilience		2	6%	3	4%

7 ANNEXURE C: Aspiration: Detailed Actions per Domain

Domain: Strategy, Management & Regulatory (SMR)

Aspiration level to be achieved over next 5 years: 2 (Enabling)

What motivates this aspiration?

- To derive the optimal benefits from the smart grid investments from a customer perspective.
- To have strategically aligned business objectives.
- The ability to apply "self regulation" and to meet the regulatory compliance requirements.

What action must happen to achieve this aspiration?

- Approval of the Smart Grid Vision.
- Promote a common smart grid vision across all lines of business.
- Smart Grid technology deployment must be aligned with operational improvement strategies.
- Enhance discussions with the regulator and promote the smart grid vision.
- Identification and prioritisation of funding requirements.
- Introduce a smart grid governance model to ensure alignment with the vision and roll out of initiatives in line with the smart grid strategy & business maturity objectives.
- Define roles and allocate responsibilities to address actions to facilitate maturity growth in domain as identified.
- Identification of resource requirements, recruitment of the optimal skills profile to complement the smart grid strategy and the alignment of the business structure.

What obstacles must be overcome to achieve this aspiration?

- Organised Labour buy-in.
- Resource constraints and business structure.

Domain: Organisation & Structure (OS)

Aspiration level to be achieved over next 5 years: 2 (Enabling)

What motivates this aspiration?

- Elimination of barriers.
- Improved resource deployment.
- Business sustainability.

What action must happen to achieve this aspiration?

- Leadership commitment.
- Alignment of the business structure to support the smart grid vision and roll-out strategy.
- Consistent communication and promotion of smarter journey.
- Define specific strategies to enhance organised labour engagement.
- Develop a communication & stakeholder engagement strategy through which amongst others the smart grid vision can be promoted.
- Participation from all LOB's in smart journey initiatives.
- Define roles and allocate responsibilities to address actions to facilitate maturity growth in domain as identified.
- Develop and introduce a change management strategy to facilitate smarter journey.
- Introduction of smart grid performance measures.
- Education and training aligned to smart grid journey.

What obstacles must be overcome to achieve this aspiration?

- Business structure alignment.
- Organisational culture and level of silo approach.
- Alignment of performance measures and compensation.
- Organisational alignment around end-to-end processes.

Domain: Grid Operations (GO)

Aspiration level to be achieved over next 5 years: 3 (Integrating)

What motivates this aspiration?

- Quality and security of supply.
- Legal and regulatory compliance.
- Safety, physical and cyber security.
- Ability to leverage near real time data in grid operations & decision making.

What actions must happen to achieve this aspiration?

- Advanced technology deployment e.g. substation automation (self-healing), advanced outage restoration, remote asset monitoring of key grid components, and advanced data communication.
- Fact-based use of grid data.
- Use of smart meters as grid management sensors in the network.
- Promote the use of smart grid data.
- Adopt & introduce industry best practice performance indicators.

What obstacles must be overcome to achieve this aspiration?

- Policy and regulatory framework.
- Technical skills requirements.
- Municipal communication spectrum.
- IT/OT integration

Domain: Technology (TECH)

Aspiration level to be achieved over next 5 years: 3 (Integrating)

What motivates this aspiration?

- Key enabler to unlock business value.
- Provides business opportunities outside the classic kWh business.
- More responsive to environment.
- Required to meet information security objectives.
- Information transparency.
- Effectiveness and efficiency.
- Enhance customer participation.

What actions must happen to achieve this aspiration?

- Address fragmented approach and skill set to respond to technology related business requirements.
- Approved enterprise ICT strategy and implementation plan.
- Identification of opportunities to deploy technology to facilitate business performance improvement.
- Improve documentation and record keeping capability.
- Review value chains and address process & IT alignment.
- Define roles and allocate responsibilities to address actions to facilitate maturity growth in domain as identified.

What obstacles must be overcome to achieve this aspiration?

- Resource constraints.
- Organisational structure constraints.
- Employment practices and retention strategies.
- ICT not seen as strategic business partner.
- Skills development and training.

Domain: Customer (Cust)

Aspiration level to be achieved over next 5 years: 3 (Integrating)

What motivates this aspiration?

- Business objective to empower customers.
- Customer enablement.
- Demand & energy efficiency management.
- Business sustainability.

What actions must happen to achieve this aspiration?

- Define roles and allocate responsibilities to address actions to facilitate maturity growth in domain as identified.
- Identify smart grid technology applications which will enhance the customer experience/benefits/improve participation.
- Review & prioritise current initiatives and align it with the smart grid vision under development and utility maturity objectives to optimise the benefits to the customers and the utility.
- Communicate the smart grid vision and relevant technology deployment to the customers.
- Promote smart metering capabilities and the ability of customers to access data to respond to the environment/ economy/grid/utility signals.
- Enhance consultation with the regulator in respect of the smart grid vision.

What obstacles must be overcome to achieve this aspiration?

- Value chain integration.
- Potential customer resistance.
- Capacity constraints to do effective equipment reliability modeling.

Domain: Value Chain Integration (VI)

Aspiration level to be achieved over next 5 years: 2 (Enabling)

What motivates this aspiration?

- To optimise the business value.
- To ensure organisational behavior which demonstrates a seamless operation.
- Focused customer service.
- Optimal investment and effective resource deployment.

What actions must happen to achieve this aspiration?

- Identification and deployment of resources that can effectively assist with the research and identification of energy storage options.
- Use of near real-time information/data to promote dynamic supply and demand management as well as information sharing within the value chain.
- Evaluation of results from utility initiatives and consistent implementation of the results identified across the business as relevant best practices for the utility.
- Introduce an energy management system for residential customers.
- Redefine the value chain in line with the smart grid vision based on the smart grid capabilities.
- Identify options and define resource portfolio.
- Public promotion of the smart grid benefits.

What obstacles must be overcome to achieve this aspiration?

- Lack of knowledge in respect of storage options.
- Consistent interpretation and definition of business value chain.

Domain: Societal & Environment (SE)

Aspiration level to be achieved over next 5 years: 2 (Enabling)

What motivates this aspiration?

- Protection of the environment.
- To enhance customer participation in managing the impact on the environment.
- Legislative compliance.

What actions must happen to achieve this aspiration?

- A documented and approved smart grid vision is required.
- The role of the utility and the goals/objectives/targets in respect of the societal and environmental domain must be documented and tracked.
- Active engagement in addressing societal and environmental matters.
- Energy efficiency programs for customers must be established.
- Multiple renewable energy options must be accommodated.
- Deployment of a smarter grid to contribute to amongst others the plant/network reliability, health, safety, security, infrastructure & effective energy management.
- Active promotion of smart grid benefits.
- Tangible demonstration of the application of a "triple bottom line" view when making decisions.

What obstacles must be overcome to achieve this aspiration?

- Customer education.
- Financial support to promote initiatives.
- Customer access of consumption data.