Journey towards a Smart Utility: an eThekwini Electricity perspective

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1. Abstract

The benefits of a Smart Grid which include improved customer service, network reliability and improved outage response exceed the current challenges experienced by eThekwini Electricity. This paper discusses the approach being followed by eThekwini Electricity in achieving its objective of a Smart Grid and the highlights the challenges being encountered by eThekwini Electricity. These challenges are not unique to eThekwini Electricity but impact on all other Electric Utilities within the South African region. The paper further discusses the achievement of a fully automated network that can ensure two-way flow of electricity and information. The implementation of various projects to meet the Smart Grid objective is also highlighted.

2. EThekwini profile

EThekwini Electricity is a one of the largest and most respected utilities involved in the transmission and distribution of electricity within South Africa. The licence area of supply within the Municipal boundary covers just over a 2 000km^2 area. EThekwini is the only metro within the country which operates at a voltage of 275 kV receiving power from Eskom at five infeed substations disbursed around the municipal boundary.

Staff Compliment: 2 240

Total Customers: 711 095

Maximum Demand: 1800 MW

Total Sales: 11 412 GWh

The vision of the utility is to be a leader in electricity distribution providing energy for the future. This vision is underpinned by its overall strategy to develop the utility as an undertaking that maximises the value of its electricity supplies and makes effective use of all its resources.

3. Our current challenges in a municipal environment

EThekwini Electricity prides itself as a progressive utility with highly skilled technical personnel who continuously explore innovative ways of improving the effective management of the utility. The implementation of these innovative ideas have placed the organisation as one of the leading utilities within the electricity distribution industry of South Africa.

The major strides and gains made in the technological space are however at times overshadowed by the vast majority of challenges faced by the utility. These challenges include:

a) Provision of electricity to customers within Informal Settlements;
b) Theft of infrastructure;
c) Theft of energy;
d) An ageing network with increasing maintenance costs and poor maintenance practices;
e) Unplanned outages from overloaded networks compounded by a rapid growth in demand and geographic expansion;

f) The lack of institutional memory as a result of experienced employees retiring without the necessary skills transfer to other employees or systems. This is resulting in a shrinking workforce that must work more efficiently and cost effectively;
g) Legacy Information Technology systems with fragmented applications. Undetected inefficiencies and misallocations of resources need to be identified; and
h) Increasing compliance requirements with respect to quality of supply and service, finance, health, safety and environment.

However, eThekwini Electricity continues to be motivated and committed due to its recognition of the benefits of achieving a smart grid. Which in the main include improved customer service, network reliability and improved outage response.

4. Smart Grid Workgroup

EThekwini Electricity has implemented, and is implementing, various projects with the aim of improving the smartness of the grid and managing the grid more effectively. The approach currently would seem to be fragmented hence, the need to consolidate all efforts to achieve a common objective. The need to consolidate all initiatives and develop a common vision and strategy for the realisation of a smart grid led to the establishment of a Smart Grid workgroup in May 2013.

The Smart Grid workgroup is directly accountable to the Electricity Executive and aligns its activities with the Municipality's Smart City vision. It also aligns with and provides input to the South African Smart Grid Initiative (SASGI), established as a mechanism for the strategic direction and implementation of Smart Grids within South Africa.

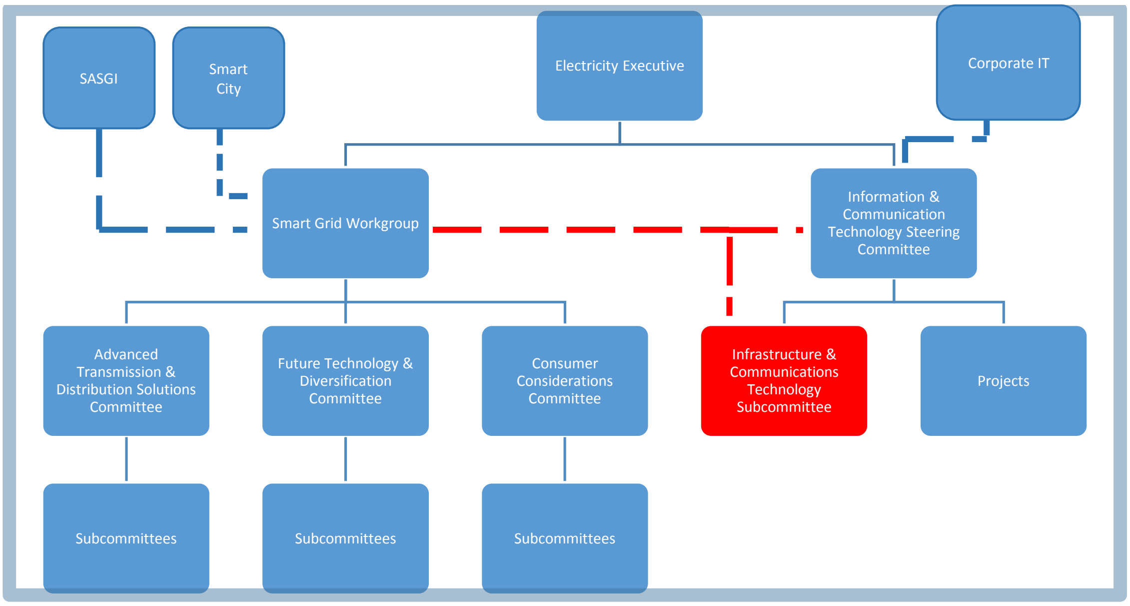

Figure 1: Smart Grid Workgroup Governance Structure

The scope of the Work Group includes:

a) Developing a high level vision of what an eThekwini smart grid might look like and the challenges it would help address;
b) Evaluating options pertaining to grid intelligence;
c) Ascertaining the level of international experience of smart grids to date and future plans;
d) The assessment of smart grid related developments within the South African electricity supply industry;
e) Establishing a baseline position ie. assessing the current network capability for smart grid applications;
f) Proposing research, development and deployment opportunities that should be pursued in the immediate future to ensure readiness to deploy smart solutions;
g) Considering pilot projects and evaluating the results from pilot projects;
h) Determining the high level costs and benefits of developing smart grids;
j) Providing input to standards and specifications; and
k) Developing a smart grid action plan which will –
    (i) Set out detailed actions required to implement the strategy; and
    (ii) Define roles and responsibilities for the different smart grid role players

4.1. Committees

The establishment of the Committees serve to provide the platform through which the actual activities of the Workgroup are executed. The scope of the various Committees are elaborated further in the figure 2.

These committees receive their mandate from the smart grid workgroup. The interaction within the committees serve to break down the silo mentality and streamline the initiatives.

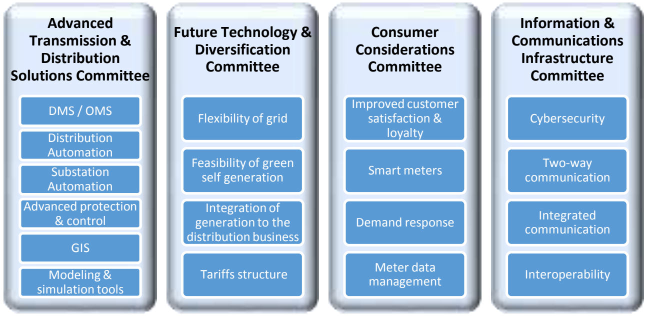

Figure 2: Committees

4.2. Smart Grid Strategy Development

The establishment of a consolidated governance structure for the utility with the workgroup as the driver of the smart grid journey has led to the need to develop a strategy as its framework and tool. The development of this strategy is not undertaken in isolation but dovetails with the utilities overall strategic plan as well as the cities smart vision.

The elements of the strategy will include, but not limited to:

a) Roadmap and action plan;
b) Technology plan;
c) Overall budget;
d) Resources required; and
e) Consolidated approach.

5. Smart Grid Maturity Assessment

As utilities consider undertaking the journey towards achieving a smart grid, and having understood what a smart grid is and why it needs to undertake this journey, there are three questions which it needs to ask itself:

a) where am I now – an “as is” analysis of the utility understanding its smart grid maturity;
b) where do I want to go – “to be” state of the utility by developing a vision; and
c) how do I get there – “roadmap” – development of a strategy.

EThekwini recognised the need to determine its “as is” condition hence, took advantage of the opportunity provided by SASGI. This involved the assessment of the utility with regard to its smart grid maturity. The methodology used was via a model developed by the software engineering institute of the Carnegie Mellon University based in the United States of America. This model has worldwide recognition and has been utilised by numerous utilities worldwide.

The Smart Grid Maturity Model — essentially a matrix of almost 200 outcomes, capabilities and benefits, plotted and tracked in various work domains — progresses through five levels of maturity. Not every utility will need, or want, to go to the last level. Depending on their situation, a utility can select which level is optimal for their smart grid vision. Level 5 (Figure 3) for example perpetuates innovation into new frontiers of the energy business. [1]

With this general progression of the “levels of maturity” in mind, let’s take a look at the eight domains in your utility that are impacted by the changes brought about by the smart grid transformation. The core business areas that are most affected in a smart grid transformation are reflected in Figure 3 as well. [1]

Figure 3: Smart Grid Maturity Model Levels & Domains

The outcome of the assessment in some ways provided an independent confirmation of what the utility had itself acknowledged, amongst other areas. The eThekwini Team is committed to explore opportunities to enhance their overall business performance and sustainability. Numerous technology implementation initiatives are taking place within eThekwini Electricity which is commendable. The technology implementation initiatives are not necessarily taking place as an integral part of an integrated smart grid strategy. The survey results reflects the level of “inconsistency and absence” of an integrated technology deployment approach (level of silo approach). The approval and adoption across Lines of Business (LOB) of the smart grid Vision, technology deployment plan and an integrated implementation strategy, will significantly contribute to the smart grid maturity level of the utility. It is essential to focus on the employee participation and the business structure alignment to support the smart grid journey. The eThekwini Team demonstrated commitment to the smart grid maturity assessment process and the participation was outstanding.

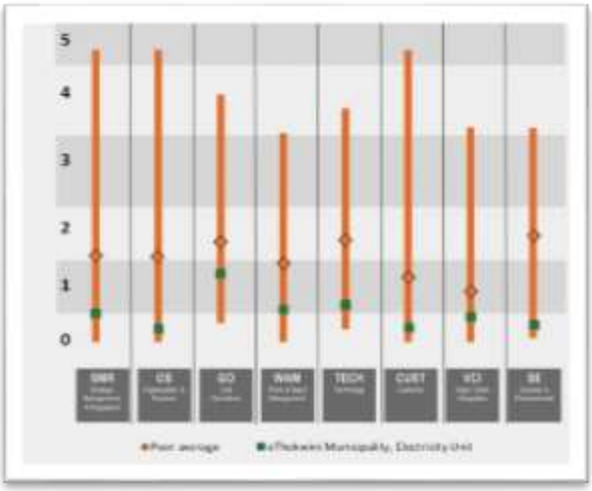

Figure 4: Smart Grid Maturity Model Peer Community

Figure 4 above provides a representation of eThekwini’s current maturity. Whilst this outcome may be seen as bleak however, it’s viewed as an opportunity for improvement and growth with an appreciation of the path that the utility needs to travel over the next few years to realise its objective of modernising the grid.

6. Implementation of various initiatives

As a utility embarks on this journey towards achieving smartness/modernisation of its grid, it’s important to get the building blocks right. Fundamental to this is having an appreciation, as a utility, as to the ownership of its assets, where are they located, what is their condition and what is their useful life. The utility has observed that the creation of a framework to manage and monitor the performance of these assets is key.

With these fundamentals in place a utility can now begin to consider introducing smartness into the grid such as:

a) Introduction of intelligent devices and sensors (automation).
b) Installation of various communication mediums between onsite devices and the back-end (Control Centre).
c) Modernised the metering infrastructure to enhance the customer experience.
d) Exploring different forms of generation and their impact on the grid.

The next section of this paper highlights the work which eThekwini has undertaken and is in the process of implementing in realising this objective of achieving smartness.

6.1. Asset Management

True SMART Grids can only be successfully implemented if you have access to information about the network, communicating it to the right people, systems and customers and enable thus self-healing functionality and intelligent decision making on the network. [2] The Asset Management Initiative deliverables support these fundamental principles thereby allowing eThekwini Electricity to harness the benefits of smart grids.

At the core of the Asset Management Initiative was the asset field verification and identification which was primarily instituted to comply with GRAP17 financial regulations, however the exercise also enabled asset management fundamentals by providing reliable and detailed asset information. This information was captured and will be stored against an equipment hierarchy that will link the technical equipment register to the financial asset register. This would enable transparent daily transactions of new additions, operations and maintenance and disposal allowing the information to be available for more informed decision making.

In order to overcome the challenges of information duplication, leading to conflicting information and lack of information maintenance processes, a draft technical information system framework was established. This will assist eThekwini Electricity moving towards integration and development of information systems and establishment of best practise processes which will mitigate technical information disparity. In support of the technical utility information system framework a draft technical utility data model was defined. The technical data model will facilitate an environment where information and information ownership is well documented and agreed. It sets the responsibilities for the various sections and personnel involved to maintain adequate data. The technical utility data model provides the perfect foundation for future system expansion and integration planning.

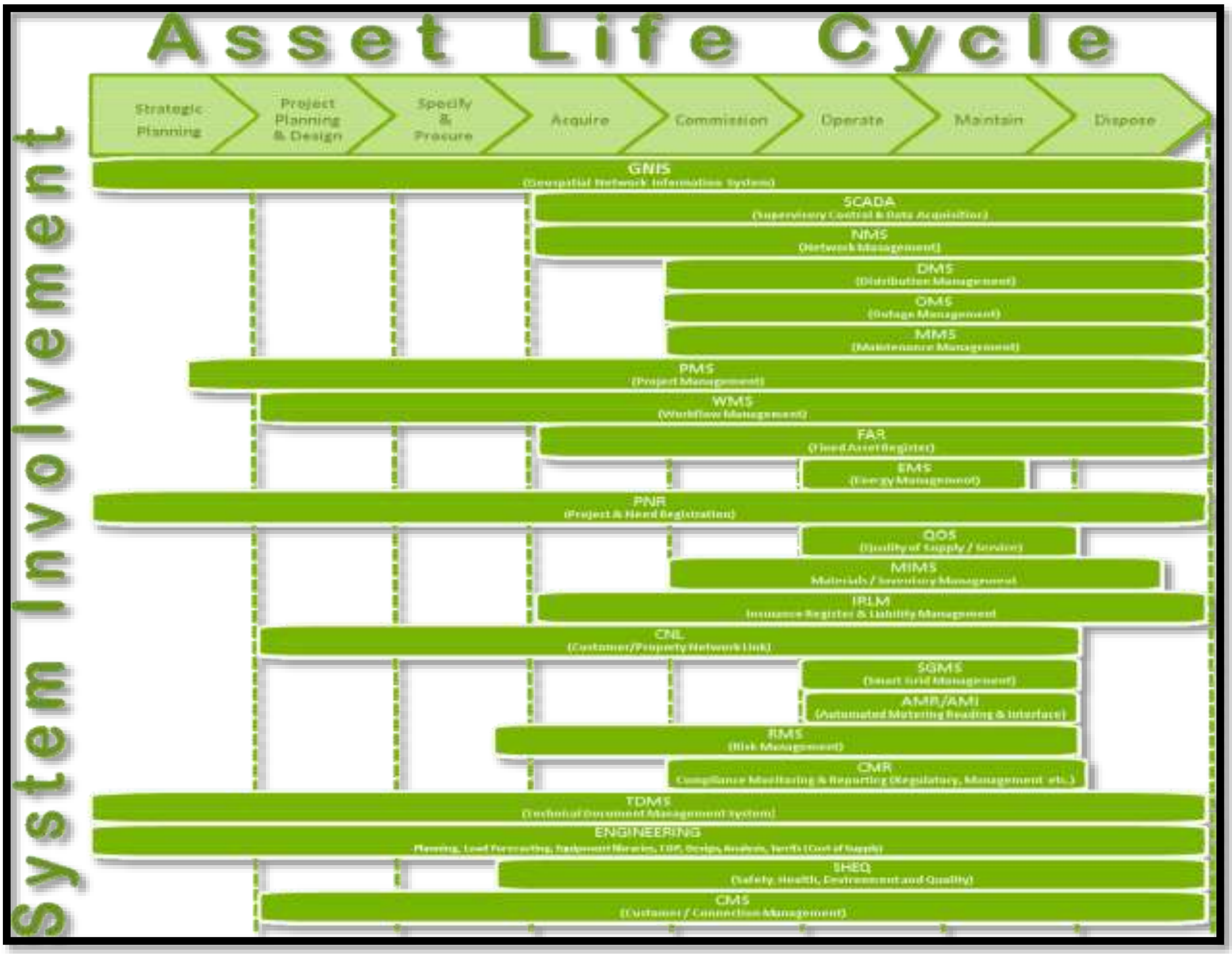

Figure 5: Systems Involvement – Asset Lifecycle [2]

As can be seen from above diagram, information integration is required to ensure all the systems have a similar and accurate view of the required asset's information, and that no one system hosts all the required information about the asset. Also various systems will play a role together to provide a "comprehensive representation" of all asset information, which can be viewed through business intelligence tools / software. [2]

The benefits achieved from improved Asset Management practices include:

a) Improving the network performance and service delivery thereby enhancing customer satisfaction and improving health, safety and environmental performance;
b) Optimizing return on investment and obtaining value for money. Cost savings can be achieved on refurbishment by extending the equipment life cycle due to improved maintenance procedures, which would have an added benefit of reducing insurance costs and levies;
c) Legal, regulatory and statutory compliance through controlled and systematic processes (KPAs and KPIs);
d) Improving risk management and corporate governance; and providing a clear audit trail for the appropriateness of decisions taken and their associated risks. There should be a balance between engineering, operational and financial risk;
e) More efficient and effective procurement would ensure that the supply chain would be better managed;
f) Ensuring that sustainability is actively considered as part of asset utilisation and selection;
g) Improving productivity as a result of better planning and targeted human resource development; and
h) Improving decision making as a result of better information being available with respect to infrastructure, people and processes.

6.2. GIS landscape

The intelligence of the smart grid relies critically on geospatial data to represent and track the locations of numerous devices within the connectivity model of the distribution system. [3] Traditionally the network reticulation records at eThekwini Electricity was stored in Computer Aided Design (CAD) package. The transformation from CAD to a Geographical Information System (GIS) environment incorporated metadata and additional intelligence to the database.

GIS at eThekwini Electricity provides a spatial platform for the technical records of all the existing network infrastructure. An updated dataset is reliant on the receipt of accurate as-built drawings from the various Works Branches and is supported by the Master Data Change process hosted by the Asset Care Centre.

As more Branches and their Divisions are exposed to and interact with the GIS they are beginning to realise the benefits of having a fully connected geospatial network data model. The revised data model has provided a platform to integrate the GIS data with other Enterprise Systems of the organisation. It has also addressed the issues of network connectivity in the GIS and provides the ability to perform network tracing.

6.2.1.Objective

The main objective of the initiative is to have a fully connected network of the high voltage, medium voltage and low voltage electricity reticulation in GIS and to have a real world geographical representation of the electrical infrastructure. Secondly, is for the provision of a platform which will allow for the interaction with other Enterprise Systems of the organisation, viz. Outage Management System, Revenue Billing System, Enterprise Asset Management System, Customer Information System, etc.

6.2.2.Progress

A new data model was designed to host the additional data from the Asset Management Field Verification project. This data model incorporates existing eThekwini Electricity's underground layers, (i.e. underground cables, communications infrastructure, cable ducts and cable joints and terminations) that were excluded from the asset verification project. In addition to the data that was collected in the asset management field verification project, the data was further enhanced with existing data from the eThekwini Electricity dataset. ArcVisio templates were designed to replicate the equipment in the field and assist GIS capture process.

The enhanced data model has been executed in a third of the network, viz. the Southern Region. Electrical network connectivity for components of the medium voltage and low voltage equipment has been achieved in this model.

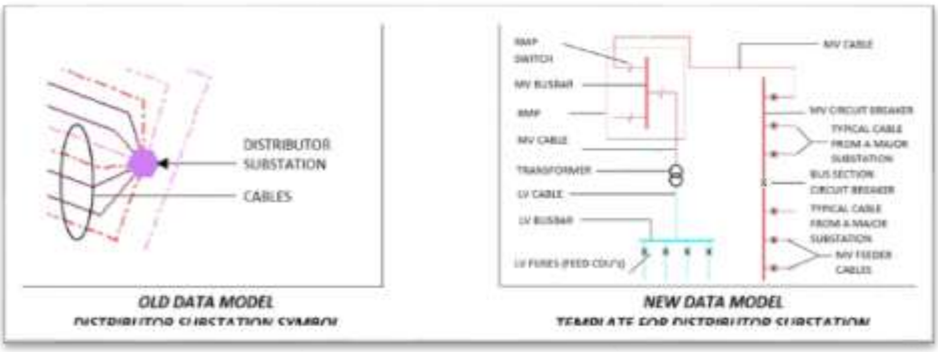

Figure 6: Comparison of Old & New data models

6.2.3.Challenges

Some of the challenges experienced include:

a) Very complex dataset with extensive attributes that needs to be maintained;
b) Reliance on the entire organisation to provide data;
c) Data discipline is a problem and needs to improve throughout the organisation; and
d) The organisation needs to adapt to new data model.

6.2.4.Benefits

Assets are better managed by having an accurate spatial record. A fully connected geospatial network database supports a quicker response in spatially locating underground infrastructure and fault finding. This also promotes efficient planning for new construction and extension to the network and for planned maintenance.

6.3. Communications Infrastructure

In considering the role of communication networks in the smart grid, it's important to emphasize that the first enables the second. Adding intelligence to the electric grid primarily means automating various grid functions. And automation isn't possible without communications networks that enable a two-way flow of data. [4]

Historically all system communication within eThekwini's electrical network was via a copper pilot system consisting of cables with varying numbers of cores.

As the copper system aged, it became susceptible to faults which are very costly to repair. As the pilot cables were also unable to meet the communication demands of a modern utility, an overall long term communication network strategy was adopted in 1994 which included implementing fibre optic based systems and wireless systems.

A new Communication Networks Branch was established to concentrate on the rapidly increasing communication requirements of the electrical network.

6.3.1.Objective

EThekwini Electricity's communication network strategy is to establish a private, integrated multi-tier, hierarchical communication network as shown in Figure 6 below.

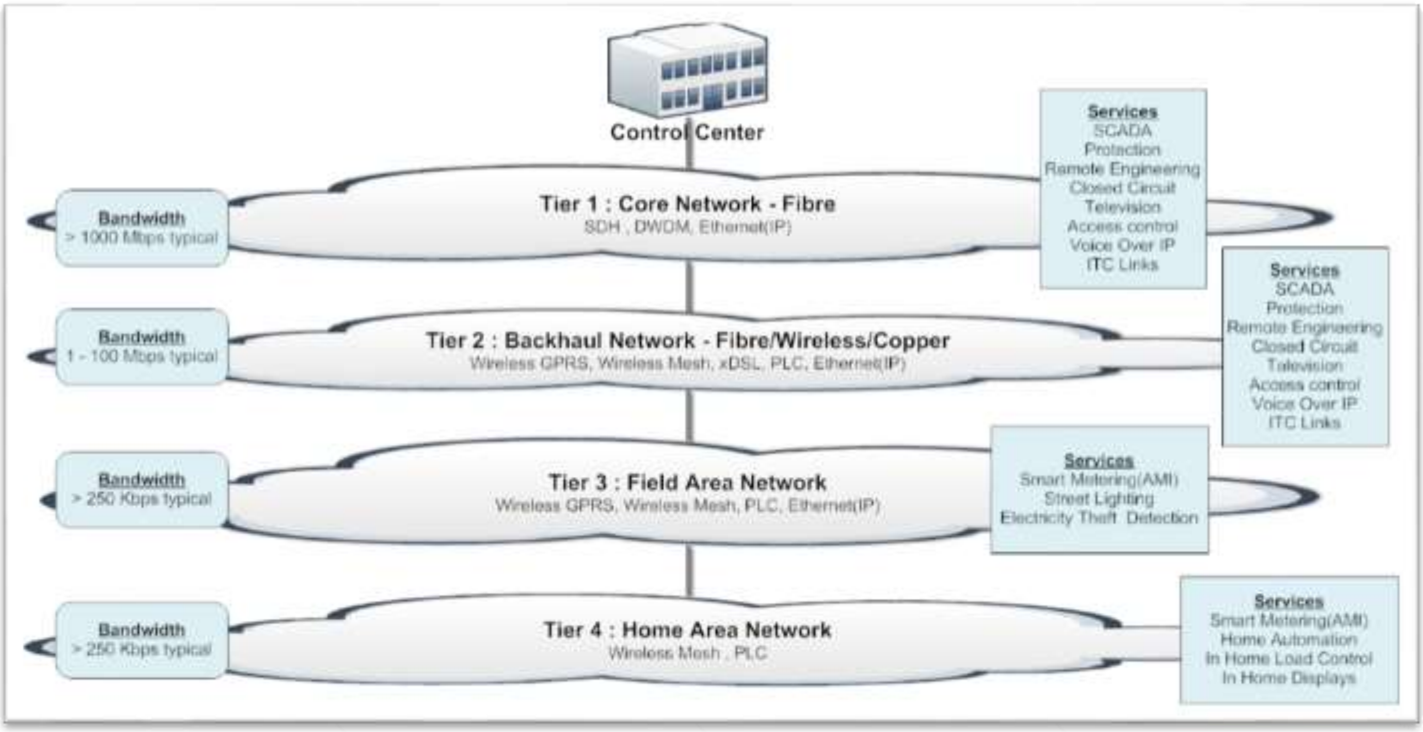

Figure 7: Communication Networks Strategy

The system is required to cover the entire area of supply. It needs to be reliable, secure and scalable. As a modern communication network it will be required to provide overall high bandwidth and low latency performance. To ensure efficient and effective operation and maintenance the system will required to be fully manageable through a centralised management system.

6.3.2.Benefits of a private communication network

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 Cost — in terms of capital and operational expenses — is greater than a non-utility alternative, the guarantee of reliability, safety and security inherent in a proprietary utility-owned network often trumps cost concerns. [4]

Table 1: Benefits of a Private Communication Network

No.	Concept	Description
1	Control	Since the utility owns the network, the utility is in complete control, able to determine quality of service (QoS) and packet priority to ensure adequate bandwidth for the most crucial business applications at all times. In addition, the elimination of public traffic removes opportunities for network overload that could render the network unavailable, for example, during a disaster. This is particular important for mission critical applications such as Supervisory, Control and Data acquisition (SCADA) and tele-protection.
2	Future proofing	Private utility communication networks are not subject to the constant protocol changes that take place for example in commercial cellular networks, ensuring that the equipment you purchase today can remain in service over the 10- to 15-year expected lifecycles for electricity infrastructure.
3	Security	Since the network is privately owned, the utility can deploy, enforce and manage standard security policies to provide the right level of protection for company data. To re-iterate this is particular important for mission critical applications such as Supervisory, Control and Data acquisition (SCADA) and tele-protection. This will also play a critical role in the introduction of Smart Metering and other valued services as both customer and consumer information will need to be secured.
4	Coverage	The utility can design the network to ensure coverage wherever it is required.
5	Capacity	The utility is in charge of managing capacity. As additional applications are added, the utility can add capacity as needed. The capacity requirements will continue to grow as the utility adopts various Smart Grid technologies and at its own pace.

6.3.3.Progress

Fibre optic cables were installed inside the earth wire on overhead line systems, (Optical Ground Wire or OPGW), as part of refurbishment projects handled by the HV Operations Department. Underground fibre optic cables were also laid together with electrical cables between major substations.

The second objective was to install a fibre optic SDH multiplexing system between major substations, and to provide connections for protection schemes, SCADA, remote interrogation of protection relays, quality of supply recorders, security systems, data communications, and other services of the electrical network. This has been achieved, and all majors are now reachable and are serviced by the multiplexer system. In addition a layer 3 data network has been at these Major substations to accommodate the new requirements for Ethernet services such as distribution automation traffic backhaul, CCTV and access control.

The fibre optic system is also used for Administration systems. All eThekwini Electricity depots have been connected using dedicated fibre links. In addition, a commitment has also been made to make a pair of fibre cores available on each route for use in eThekwini Metro’s broadband venture, MetroConnect.

Cellular radio technology was introduced to provide the communication channel back to the Control Centre. This provided communication links to the approximately 800 distributor substations of the intermediate 11kV level of the electrical system. Although not under internal control, this technology was accepted as an interim solution due the readily available infrastructure and extensive coverage, which enables fast roll-out throughout the region.

These allowed the ability to connect mini-RTUs and RTUs of new IEC61850 distributor substations to the Control Centre, for automation purposes. This cellular system will most probably also be initially utilised in linking up mini substations, autoreclosers and other remote equipment in the electricity system.

A focus has also been placed on network management with modern systems being procured to support the evolution towards Ethernet services with the electric utility environment.

The current focus is on setting up a private tier 2 communication network to cater for the above mentioned 11kV level of the electrical system. Progress has been made by initiating a proposal to install fibre optics to all distributor substations as well as undertaking a pilot project to rollout a carrier grade wireless mesh solution.

6.3.4.Challenges

Challenges in deploying, operating and maintaining communication infrastructure include:

a) Recruitment of competent technical staff compounded by trying to support aggressive employment equity practices.
b) Lack of support from administration sectors of the organization ranging supply chain management to approval of dynamic organizational structures to cater for evolving business needs.
c) Adoption of the correct standards and technologies as new ones continue to emerge.
d) The need to support of legacy systems.
e) The reluctance or inability to accept change within organisation.
f) Missing core functions, processes and fundamental practices ranging from work planning and control cycles to project management.

6.3.5.Lessons

The largest lesson learned was the need for an overall strategy within the organisation to ensure massive needs and changes required to implement a smart grid is met. An example would be eThekwini Electricity's initiative to update its medium voltage planning and construction processes to include the planning of communication infrastructure to accommodate future smart grid applications. Attention needs to be paid to the operation and maintenance strategies of systems as these are often overshadowed by the installation and commission phase of a project in excitement of adopt new technologies.

6.4. Distribution Automation

EThekwini Electricity has a long term goal to obtain full Supervisory Control and Data Acquisition (SCADA) visibility throughout the distribution network, therefore aims to install intelligent devices to remotely manage and control all medium voltage equipment in the distributor substations, ring main units, autoreclosers, mini substations, and kiosks, to ensure network reliability. EThekwini also aims to install through fault indicators to monitor the overhead mains (OHM). The Distribution Automation project has been broken down into three phases and each phase further subdivided into the respective order of priority for which the DA project is currently being deployed (See Figure 8: Distribution Automation project breakdown). DA aims to ensure a secure, reliable and safe network in alignment to a smarter grid.

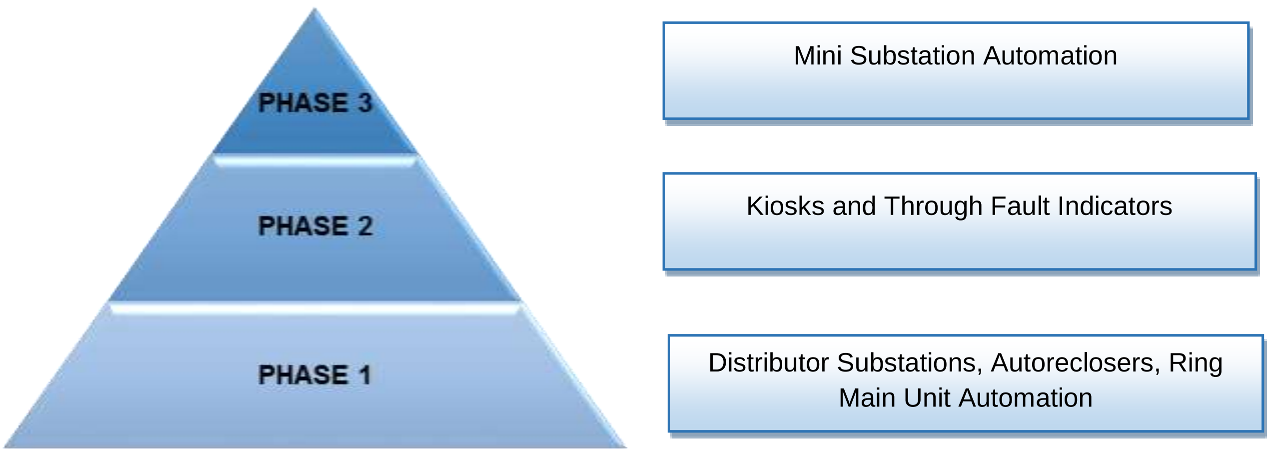

Figure 8: Distribution Automation project breakdown

6.4.1.Benefits

Improves data acquisition for engineering and strategic planning of the network by making valuable information available to the planning and construction divisions who will further influence the future reinforcement and operation of the network.

Improves network performance by reduction in system outages and greater security of supply. This is made possible by the intelligent SCADA system which allows the controllers to monitor and manage the MV network in real time.

Improves operator efficiency and safety – controllers are made aware of faults as soon as it occurs by receiving alarms and can therefore respond quicker to a fault, monitor the loads at each substation and remotely control switchgear, improves the controllers visibility to unsafe or insecure situations on the network.

The intelligent devices allow for early detection of equipment failure and assists in Fault location hence improves restoration times.

Enhances overall customer service – improved detection and restoration of faults hence, reduced outage times and feedback to customers on the status of outages.

6.4.2.Progress

Remote Terminal Units (RTU) have been installed and commissioned in 455 distributor substations from a total of 755. A total of 507 of these distributor substations have been wired. The main objective of this project is to enable remote monitoring and control of distributor substations and these RTUs allow for remote data acquisition and control to these substations. The status of these sites are regularly monitored to ensure communication to the intelligent devices. Communication to the RTUs were made possible by the installation of Internet Protocol (IP) Modems using GPRS. The advantages of IP communication include the ability for engineers to do updates, configuration changes and remote diagnostics of faults without the need to drive to site, thus improving the response times to faults. Open VPN was implemented to take care of security vulnerabilities that GPRS introduces.

Figure 9: RTU type A

Figure 10: RTU type B

A total of 71 ring main units have been installed where 9 of these sites have been commissioned and a total of 74 autoreclosers have been installed with SCADA functionality but none have been commissioned.

Two through fault indicator (TFI) sites have been configured and commissioned for testing purposes to monitor the performance of the devices and ensure it meets eThekwini Electricity's requirements. The TFI will serve as an indication to the Faults personnel as to where a fault occurred on the OHM. 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 the Control Centre to notify the controllers that a fault has occurred and the faults team can then be dispatched as soon as possible to repair the fault.

The kiosk pilot site has been tested and commissioned. The first batch of kiosks are currently being wired and prepared for the mini RTU installation. This will allow the controllers to detect when a fuse is blown and obtain earth fault indications as well as the current loads of the substation.

6.4.3.Challenges

Physical security, vandalism and theft on the electrical network are a growing concern. Communication media – GPRS in some locations are unreliable due to the low signal strengths.

6.5. Advanced Metering Infrastructure

The Advanced Metering Infrastructure (AMI) programme is responsible for the implementation of Smart Metering which entails installation of smart meters, associated equipment such as communications modem, Customer Information Units (CIU) and Data Concentrators (DC) as well as Multi-Vendor Master Stations (MVMS) and Meter Data Management System (MDMS). Integration of all these components will ensure a seamless end-to-end bi-directional communication flow. This initiative will enable eThekwini Electricity in its effort to achieve their broader objective of implementing smart grid in their areas of electricity supply. AMI will also ensure consistency and optimisation of similar metering initiatives within eThekwini Electricity. The AMI programme will align to the overall eThekwini Electricity's smart grid objective that entails a sustainable and medium to long term strategy. This strategy is also an essential part of eThekwini Municipality overall vision of creating, among other priorities, a safe, accessible, environmentally sustainable and economically sustainable city by eventually achieving a smart city objective.

6.5.1.EThekwini Solution

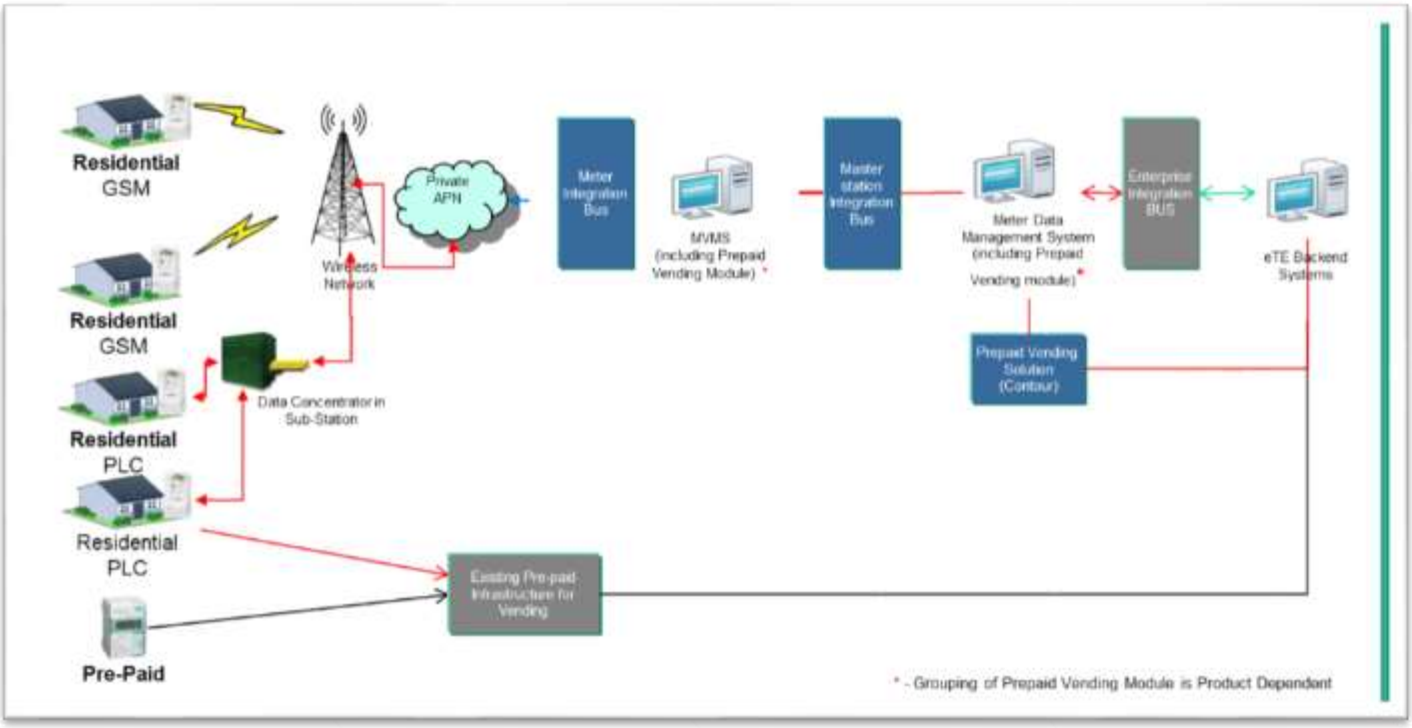

Figure 11: eThekwini AMI Solution

The eThekwini AMI solution:

a) relies on the implementation of a Multi-Vendor Master Station;
b) relies on the implementation of a Meter Data Management System;
c) requires AMI meters;
d) requires one or more Field Installers (Service Provider) to install the AMI meters;
e) requires communication infrastructure to facilitate communication between meters and the MVMS. The current view is that this will be achieved through GPRS over eThekwini's existing private APN;
f) will leverage its existing Prepaid Vending Solution; and
g) will leverage eThekwini's existing Prepaid infrastructure for prepaid vending.

The conceptual diagram below shows the key elements in the end state.

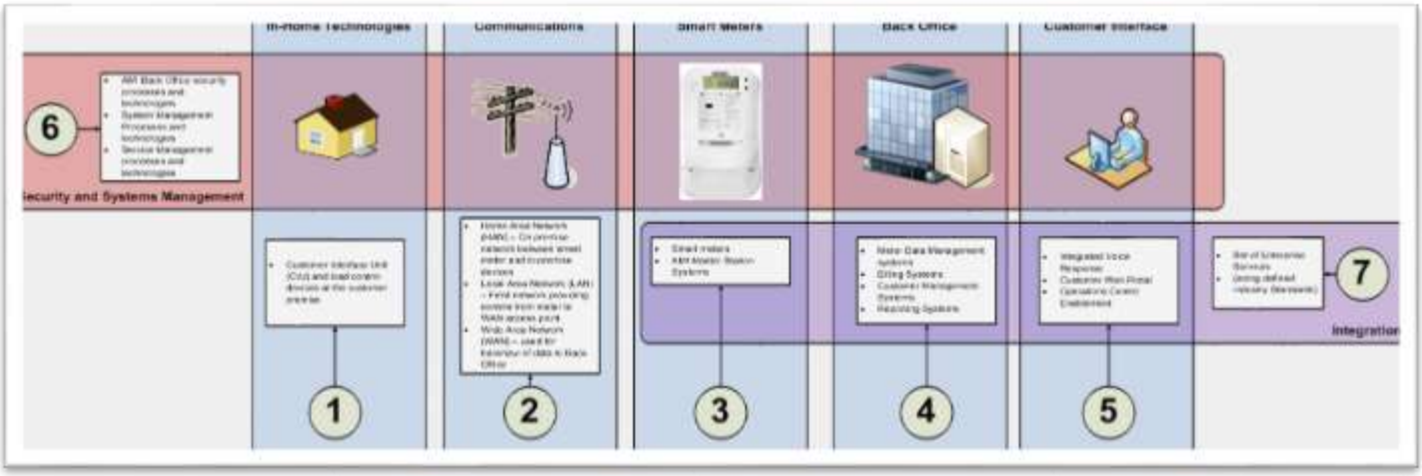

Figure 12: Conceptual Compartmentalisation of Solution Components

Table 2 below provides a detailed description of the various components outlined in the conceptual design reflected in figure 12 above.

Table 2: Conceptual Component Descriptions

No.	Component	Description
1	In-Home Technologies	Customer Interface Units Display and load control devices at the customer premise, interconnected with the utility's systems via a Home Area Network (HAN).
2	Communications	Network technologies that interconnect the various Smart Meter Infrastructure (SMI) components.
3	Smart Meters	Smart Meters and the associated AMI Master Station System
4	Back Office	The eTE systems providing customer management and billing functions.
5	Customer Interface	System providing direct interface with the customer such as Integrated Voice Response (IVR) and the customer web portal.
6	Security and Systems Management	Security and other management systems used to maintain, monitor and manage the infrastructure and application environment.
7	Integration	Enterprise Integration Architecture (EAI) is the integration framework composed of a collection of technologies and services which form a middleware to enable the integration of systems and applications across the enterprise.

6.5.2.Progress

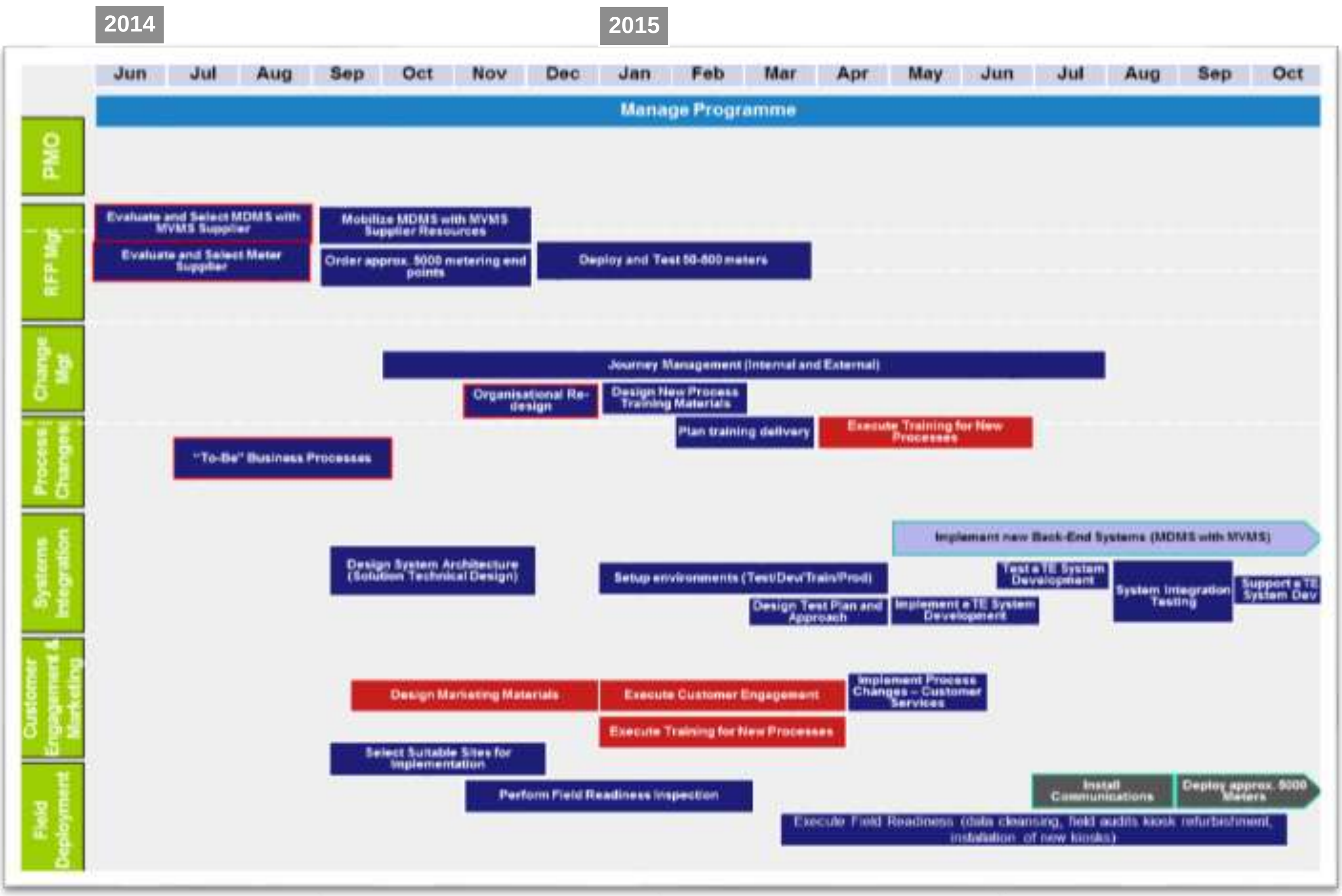

Figure 13: AMI High level Timeline

6.6. Embedded Generation

Load Shedding and the rising electricity prices have forced customers to become more aware of their electricity usage. The pay back periods and viability of small scale embedded generation projects have also become more feasible. Small scale generation projects especially rooftop photovoltaic (PV) are now becoming a popular sight within the city of Durban. Customers are procuring pre-packaged solutions either locally or shipped from international suppliers. With little technical knowledge and good handy man skills, the pre-packaged plug and play solutions become a kilowatt hour generating machine as it absorbs the sun's rays that glow upon the city.

There seems to be a reluctance to couple batteries to the generation systems with the tendency to synchronize the system to the municipal grid. There are numerous advantages in such a scheme, as it allows for the grid to act as a virtual battery when the local generating plant produces more kWh's than the household requires. This eliminates the need for expensive battery technologies and related maintenance/disposal procedures.

Whilst the advantages make synchronization a logic choice, it also triggers the need for technical, safety and regulatory compliance. With this concept being relatively new, there is lack of clear guidance in terms of how these generators need to be treated. Industrial role players are trying to propose solutions; however there are many challengers to overcome prior to the introduction of a holistic solution. It is of extreme importance that a national framework be introduced immediately, as reverse power flow onto the network creates safety and technical hazards amongst other issues.

EThekwini Municipality has come under tremendous pressure from the public, to introduce a mechanism to allow for the export of generated energy. Many installations have gone ahead without approval from the city and this has resulted in meters reversing, posing a severe financial risk to the municipality. Unknown reverse power flow also creates a safety hazard. If left unattended, the situation would become unmanageable.

In an effort to gain control and manage these installations better, eThekwini Electricity has taken bold steps in implementing an interim small scale embedded generation framework. Some of the steps taken include the proposed implementation of a residential embedded generation tariff to create a simple buy back mechanism for generated electricity.

In providing an electricity supply to any residential consumer, eThekwini Electricity levy charges by means of a tariff structure to recover costs incurred in providing such a service. There are a variety of costs, however for the purpose of simplicity within the context of this paper, the cost can be viewed as follows:

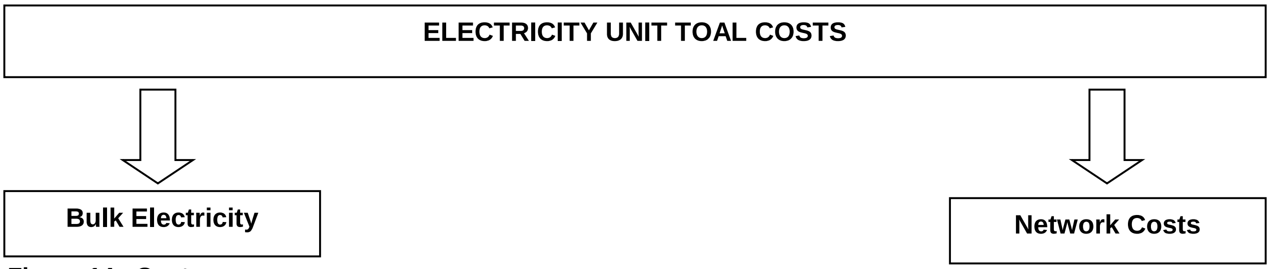

Figure 14: Costs

The Bulk Electricity costs refer to the costs that are paid to the generator of the electricity which is Eskom. Whilst the Network Costs refer to the fixed costs incurred by eThekwini Electricity which includes costs such as repairs and maintenance, salaries, meter reading and related costs. Stemming from the above, it can be concluded that there are fixed and variable costs associated with a supply point, irrespective of the direction of power flow. Residential users currently pay for both costs via a single rate energy charge (per a kWh).

The introduction of this new tariff allows residential customers to consume electricity from the grid as well as export generated electricity to the grid. As a result of implementing such a mechanism, the municipality runs the risk of a financial loss. If the customer generates as much as consumed, then the payment to the municipality is zero. To ensure no free riding on the network and the risk to the municipality is limited, a network recovery charge is needed. The current tariff recovers the network charge as electricity consumed. Whilst this is not cost reflective, it is workable and has been successful in recovering the network charge in the past. To ensure consistence and equal treatment amongst the residential sector, it was proposed that a network access charge be recovered via an energy usage mechanism.

All generation sites need to be metered and metering of these small scale embedded generation sites are done by electronic bi-directional meters which record both the import and export kWh's. These readings are then fed into the billing system which had to be programmed to manage this complicated residential embedded generation tariff.

With regards to the license requirements of small scale embedded generators, eThekwini Electricity together with SALGA and the AMEU have put together a request to NERSA regarding generation license requirements for small scale embedded (< 100 kW) generators and still eagerly await the outcome of this request.

At the outset of this journey, there were lack of policy and guidelines guiding embedded generation but over the years, there has been progress in the creation of guideline and policy towards embedded generation namely; NRS 097, South African Renewable Energy Grid Code, SANS 10142-3 which eThekwini Electricity has been a part of. The eThekwini Electricity framework is in line with the latest codes and standards to ensure that all generators comply with the necessary regulations.

A simple application form that can be obtained from the eThekwini Electricity website has to be filled in by any resident wishing to synchronise with the municipal grid. The form needs to be furnished with details of the technical specification of all the generation equipment. This is then evaluated and if it meets all the criteria then approval to connect onto the grid is issued. Upon completion of the installation, a certificate of completion needs to be submitted to eThekwini Electricity signed off by a professionally registered person to certify that the installation complies with all the technical and safety standards.

The above simple process to promote small scale embedded generation has been developed but is pending the approval of the Residential Embedded Generation Tariff by NERSA and clarity on the generation license requirements.

Failure to implement a policy of this nature will result in the non-promotion of small scale renewable technologies by local government. This is unfavorable as national Government has pledged its support to promote renewable technologies.

7. Conclusion

The challenges in a municipal environment are immense, especially when electricity provision is an essential service and a cash-cow. Due to these challenges, it is quite easy for a utility to get bogged down in dealing only with its operational mandate as opposed to having a strategic view on its long term vision.

This paper has clearly demonstrated eThekwini's intention to modernise its electric grid over the medium to long term. This intention embraced by the utilities executive management and is driven at a senior level with a strategic focus. There is acknowledgment that this is a long term journey however, eThekwini has commenced its walk on the path towards a smart utility via a co-ordinated and systematic approach.

Collaboration by the various stakeholders within the industry is crucial in ensuring the successful achievement of a smart and modernised grid within the country. The Department of Energy is key to provide the policy imperative and budget where necessary; SASGI to consolidate national efforts, provide strategic direction and support the development of standards; National Energy Regulator of South Africa to provide the regulatory framework; Manufacturers via the innovation and appropriate technology; and buy-in from the Customer.

8. References

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