Smart Metering Implementation Guidelines

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1 Introduction

Smart Grid and in particular Smart Metering are being installed by utilities internationally. Very large investments are made in upgrading the “smartness” of the utility distribution networks as well as metering installations. Manufacturers are releasing new smart equipment on the market every day and every offer seems to be the solution to all challenges facing utility managers. Especially the financial managers may perceive these technologies to be a quick fix for their revenue losses and financial viability. The big challenge however is the substantial investment (financially and skills) required to install and operate the new devices.

The obvious question arises: “What should my utility do to ride this new wave of technology and how should we go about doing it, if at all?”

The basic definitions and functionality of Smart Metering systems and the approach to ensure effective rollout and operation of these systems are discussed. The implementation of smart metering in the South African context concentrating on the objectives and strategies will be discussed without digging into complex technical detail too much

2 Smart Grids and Smart Metering

Smart Grids (SG) include Smart Metering (SM) and is essentially a process of installing intelligent devices in distribution networks to monitor and control the system by using computer and data communication technology. All these devices are linked to the utility back office computer systems via communication channels to transfer data from and to field installed devices. The power of the SG (Smart Grid) is embedded in the use of this information to control and manage the distribution system to improve reliability and efficiency.

According to the SANEDI (South African National Energy Development Institute) vision document a smart grid includes the following functions:

- Advanced Metering Infrastructure (AMI)
- Customer Side Systems (CS)
- Demand Response (DR)
- Distribution Management System/Distribution Automation (DMS)
- Transmission Enhancement Applications (TA)
- Asset/System Optimization (AO)
- Distributed Energy Resources (DER)
- Information and Communications Integration (ICT)

What is SM?

AMI (Advance Metering Infrastructure) or SM (Smart Metering) is a component of the SG and includes remote metering, load control, remote connect/ disconnect as well as establishing a bidirectional link from the utility to each customer service point. This is more than often the first and a very important component rolled out in the SG implementation strategy. SM enables direct communication with the customer consumption metering via various communication media. The utility is able to read consumption as well as information regarding the state of the meter and basic power quality parameters like voltage levels automatically. The profile of the customer consumption can also be recorded as well the tariff updated when required. The customer on the other hand can access his consumption and billing information via the CIU (customer interface unit) or on the utility website via the internet. Many utilities also provide smart phone apps to access customer and consumption information. The basic connectivity between field device, utility and customer is thus established in this first phase of implementing SG technology. SM eliminates a number of manual processes like meter readings, disconnections, meter audits and load management. It also creates a medium for the customer to take ownership of his consumption with near real-time information.

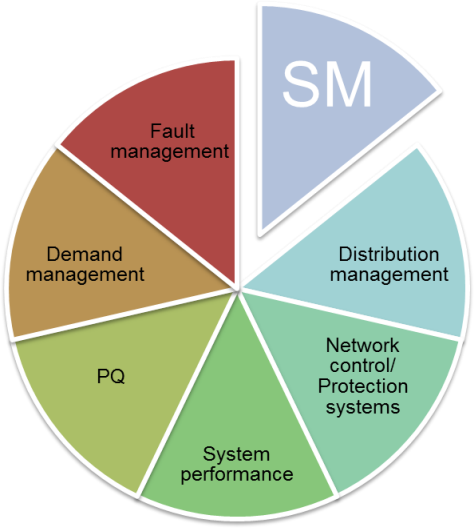

Figure 1: SG functional components

3 What is the investigative process to implement SG?

The SANEDI “Smart Grid Vision 2030, March 2013” document proposes the following methodology. The methodology is not cast in stone but provides a guideline of the processes required.

- Vision, What do you want to accomplish
- As is analysis: Where are you now
- Gap analysis : What needs to be done
- Strategy and road map: How do I get there
- Use a pilot installation to evaluate functionality
- Business case and value position: What will the cost and benefits be
- Functionalities required: What does the system have to do for me
- Implementations, system components, roll out and operation

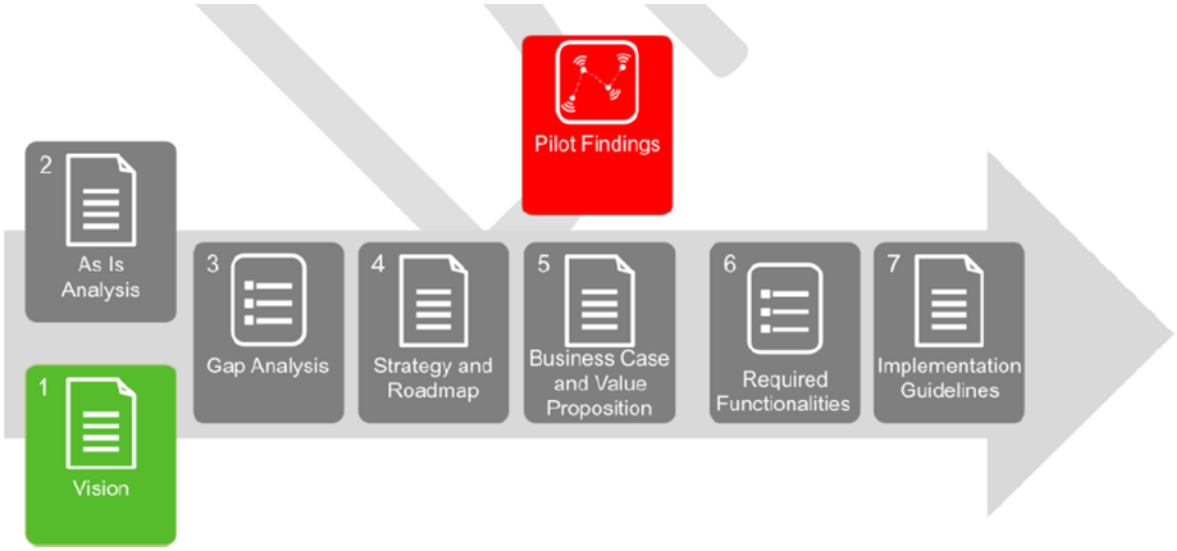

Figure 2: SANEDI SG implementation stages

4 Why and how do utilities implement SM systems

4.1 System Objectives

- **Meeting Legislative requirements**

  In many countries regulatory requirements motivated the switch to SM. Utilities were normally given a target date for conversion to SM systems and had to plan and implement the SM systems in their distribution operations. Some countries offered some government grants to partially fund the implementation of the required technology. The drivers for the legislation can be different in the various countries but in South Africa the main driver for the promulgation of regulation 773 of July 2008 was the shortage of generation capacity. The regulation basically requires all customers with an average consumption of more than 1000kWh per month to be served via a smart metering system on a time of use tariff. The SM should also be able to control non-essential loads like water heaters. The main objectives were thus to reduce electricity use by implementing more efficient technologies.

- **Solve revenue/ unit losses**

  Many utilities in South Africa experience substantial losses in terms of technical, non-technical as well as revenue collection losses normally referred to as ATC&C (Aggregate Technical, Commercial and Collection losses). The implementation of SM enables utilities to use technology as a tool to improve the management of the losses in the value chain by improved meter reading, tamper detection, meter failure detection as well as revenue management processes supported by SM and back office computer systems. Utilities will however have to realise that the systems are merely tools and by itself cannot solve process and procedure problems. It needs to be used and managed very well to realise the required end effects.

- **Improve operational efficiency**

  Many operational processes are very manual and cumbersome. By installing SM the utility has a direct view of the distribution network up to the point of service point. Traditional SCADA system could only give an indication of the high voltage network status. Outages will be visible to operational staff via the SM and SG communication system and enable them to

react timeously. The visibility of the network will also improve the outage restoration process and improve network availability.

- **Improve customer service**

  Customer service normally lacks in the reliability of metering, meter reading and correct billing. Customers should be better informed regarding their consumption levels and billing information. SM could improve the service to customers.

4.2 Policy objectives

Policies will have to be developed to address the following subjects to ensure that a utility derive maximum benefit from the installation and operation of an AMI.

- Target customer groups

  The utility should clearly define which customer groups to target with the new technology. It would not make financial sense to install highly sophisticated equipment to manage a very small consumer where the existing metering system may be more than adequate.

- Target geographical areas

  The utility should ensure that specific geographical areas are identified for the roll-out. Most communication systems used for SM are financially more effective if implemented on higher density dwellings in a specific geographical/ distribution area.

- Electricity tariffs for smart metering

  SM is capable of implementing TOU tariffs as required in regulation 773. Tariff policies should thus include a residential TOU tariff structure.

- Enhance the bylaws to support the policies

  Municipal utilities should update their bylaws to allow the use of SM, TOU tariffs and remote disconnection as well as load control facilities.

5 Business drivers

The following business drivers should be taken into consideration when motivating the installation of a SM system and also quantified in the business case for the project. Be however very specific in your utility to address the most pressing issues first. It is hardly ever possible to solve a multitude of challenges all at once. Plan the total project but use a phased approach and concentrate on the items that will have the most dramatic effect and implement that functionality first.

- Legislative
- Operational efficiency
- Customer services
- Revenue improvement
- Loss reduction
- Cost reduction
- Energy efficiency

6 Cost factors

6.1 RFP/ Project consultancy

The planning and roll out of a SM system is no trivial task. It requires technical, project management and experiential skills. It is hardly ever possible to use your line staff to perform their daily job as well as manage a time and knowledge intensive project like SM. Seriously consider contracting of an

experienced company to manage your project and assist you during the SM planning and implementation process. Do this from day one. SM is probably one of the most complex systems that utilities will be implementing. It needs a multi-disciplinary approach to be successful.

6.2 Metering installation and maintenance

The quality and reliability of a SM system is heavily dependent on the correct installation and implementation of the meters in the field. Consider the cost of installing and maintaining the meters carefully. Plan the installation effectively, contract the right company for the installation job and make sure your staff acquires the correct skills in the process. You install once but maintain equipment for 10 years after the initial roll out.

6.3 Communication installation and operation

An important cost factor to take into consideration is the installation, maintenance and operation of the communication system. Effective SM operation depends on a reliable cost effective communication system and one should consider the options carefully. The choice of communication systems could make or break the reliability of your SM system. Maintenance cost could escalate beyond financial viability if you have to battle to keep the system operational. Customers will lose faith in your system very quickly if it simply does not work or they receive estimated readings on a brand new state of the art system.

6.4 Back office systems and software

EIM (Enterprise Information Management) enables raw data to be turned into information, intelligence, knowledge, and wisdom. As information systems are becoming critical to the success of business, information management must be dealt with holistically. This component can be very expensive to install and operate. Especially in smaller utilities the meter data management and analytics which is a vital part of the SM system could cost a major portion of the system investment. Many IT companies provide a cloud based service where all the complex software is available to a utility on a contract basis. The system, software and functionality are thus supported by a service provider and the utility staff can concentrate on the utilisation of the system. These systems provide the following functionality:

- Enables utilities to take ownership, responsibility and accountability for the improvement of data quality and information accuracy and consistency.
- Enables utilities to establish single version of truth for data over time.
- Improves utilities process and operational efficiency and effectiveness.
- Provides a strategy and technique to mitigate the risks as well as maximize the value of implementing commercial packaged applications.
- Reduces the number and effort of integration over time.
- Enables the control of unnecessary data duplication and proliferation.
- Enables a more flexible and scalable process integration.
- Improves the data quality, integrity, consistency, availability, and accessibility over time.
- Maximizes the return on investment of SOA (service oriented architecture) technologies.
- Establishes a critical component of the Enterprise Architecture.
- Provides guidance and services, and enables consistent implementation of SOA and information management across major programs.
- Provides the essential meter data management and analytics engines required to manage and process meter data

6.5 ICT systems

Systems integration, particularly for municipalities, of many of the automated systems traditionally used by large utilities can be cost prohibitive – not only in terms of their purchase price, but in terms of the resources tied up to properly implement and support them. A municipality needs an incremental "bottom-up" way of building its smart grid - where each increment is built according to the highest business priorities while contributing to an overall long term master plan. Some form of services-driven automation is most appropriate for this situation, where each service can be owned/leased/operated or outsourced by the utility. Whether achieved through 'solutions as a service' or not, the key to success will be establishing a SOA (Service Oriented Architecture) and analytics integration infrastructure based on 'non-silo' data. To achieve service-oriented integration design, technical interoperability (using standards such as Web Services) and semantic interoperability (using standards such as IEC CIM) must both be addressed.

6.6 Skilled staff

The reskilling of staff on new procedures and technology is probably the most under estimated component of implementing a successful SM system. The complexity of the new system is often not realised until it is too late and it becomes a real challenge to effectively use the new systems. Officials and customers lose faith in the new system and it could become a burden rather that a solution. Take the cost and time into careful consideration when a SM deployment is planned. Get all stakeholders involved and ensure that each person knows what is expected of him/her. Train and empower people to use the new system effectively. Municipalities are particularly prone to bad communication between sections and departments and this could affect the successful roll out very negatively.

7 Possible benefits

The following possible benefits could be realised by using SM systems. Remember however that the SM system is the tool that should be used by your highly skilled staff. Choose the functionality required by your institution and make sure that the correct processes, staff and motivation is in place to realise your benefits. Manage the system intensively by using dedicated staff. It will not work all by itself. Do not fall in the trap of throwing money at a problem, buy all the best technology and not manage it effectively.

- Operational efficiency
  - Improved processes
  - Network visibility and upgrading
  - Outage management
  - Maintenance management
- Customer satisfaction
  - Personal energy management,
  - Cost and consumption feedback
  - TOU tariffs
- Energy efficiency
  - Peak demand and network management
  - CO2 emission management
  - Reduction in energy consumption per customer
- Demand response
  - Optimizing network load
  - Energy sourcing optimized
- Revenue protection
  - Tamper and fraud detection
  - Improved billing and revenue collection
  - Non–technical loss reduction
- Revenue collection
  - Improved meter reading processes
  - Improved billing accuracy

    - Better Revenue management
    - Improved cash flow
- Systems integration
    - Improved management of information
    - Improved management decision making
    - Information availability to all stakeholders including the customer

8 How do I plan the roll out of a system

- Get professional assistance
- Know what you would like to accomplish
- Clearly define the objectives
- Define a strategy to address the objectives
- Take all cost factors into consideration
- Ensure that you acquire proven technology from a company that will support you for the life of the equipment. SM technology has improved significantly over the last 5 years. You do not have to be a pioneer by buying unproven technology and risk incompatibility, supplier lock in and ineffective technology solutions
- Stick to the correct standards to future proof the system as much as possible
- Ensure that the new system is integrated into your existing system but also adaptable to any new systems you may acquire in the next 10 years.
- Ensure that your staff is effectively skilled
- Acquire the services of reliable system support staff or outsource to expert companies.

9 What happens to my current systems

Legacy systems will have to co-exist with newer systems like SM back office and metering systems. The planning of new systems will have to accommodate older meter systems e.g. accept manually read meters, existing prepayment systems as well as financial and billing systems. One of the big challenges in the implementation of newer systems is the integration with older systems. No utility will be able to replace all existing systems in the short term.

As far as metering systems are concerned older and new SM systems can co-exist. The utility may have a strategy to retain say existing prepayment systems in entry level consumption areas. Integration of consumption and sales data can take place in the meter data management system or the billing system. Processes will have to be adapted to accommodate new and legacy systems to be effective.

10 SM component selection

10.1 Use proven technology

It is essential to use proven technology. So many examples of unreliable SM components can be cited and it is not necessary to re-invent the wheel. Also be aware that many eastern countries sell their products under different brand names. Ensure that you know who the actual manufacturer is. Rebranded items can easily be discontinued and components from other sources be offered.

10.2 Use a proven set of standards

Do not use systems with proprietary technology or meter system protocols. It will catch up with you and cost you dearly. Although inter-operability is still not generally possible at this stage of technology development it should be available in the near future. Any interoperability between different suppliers implementation will have to make use of proven standards. It is thus essential to support acceptable open standards in all sections of a SM system. Let your professional advisor or consultant investigate and recommend a suitable set of standards for your equipment. Although technology ages very quickly a good set of standards implemented in the SM system will ensure that older and newer technologies can co-exist A lot of work by many experts has resulted in many good and proven standards being adopted by the major standards organisations. Typical standards applicable to South Africa include the following:

- SANS, IEC, CENELEC, EN, DLMS/COSEM, CIM , STS

11 Implementation team

- Experienced project management

  Use well experienced project managers. The team should include all stakeholders (departments and sections from finance to technical staff) and problems that may arise during the installation program should be addressed immediately and effectively by the team.

- Experienced installation teams

  Ensure that the installation teams are experienced and well trained to install and test installations in the field. Remember that these teams also interface to your customers. Make sure that they assist customers and not aggravate them.

- QA processes

  A well designed and managed QA (quality assurance) team is vital to ensure that the installed systems have been installed according to specifications and it is functionally sound. Rolling out large metering and communication systems without an effective QA process is a good recipe for disaster and many customer complaints.

- Installation data management

  Many meter installation projects have landed up in a situation where the installation data was not captured correctly. It immediately means that you do not know which customer is metered by what meter. All your billing will be incorrect and in many cases you will not know where the meter has been installed. This will require a costly audit to correct the meter data. Manage it from day one and ensure that your customer/ meter database is clean and correct.

12 Risk factors

- Vendor lock in due to proprietary equipment

  Acquire equipment manufactured to operate on open standard communication protocols. A proprietary system will only be available from one supplier and if that supplier stops manufacturing of a particular product your installations will be at risk. Proprietary systems may also lock the utility in to purchasing equipment from only one vendor. This could prove to be a problem with municipal tender legislation

- Unreliable communication systems

  Obtain communication services and equipment from proven suppliers and systems that have extensively been tested in the field

- Under skilled personnel

  Ensure that your staff is effectively trained and informed about the operation of the new system. Unskilled staff can sink your system very effectively.

- Technology aging

  Technology ages very quickly resulting in obsolete systems and meters long before the planned lifespan have been reached. SM systems are being improved at a significant rate. By using standardized equipment one can “future proof” systems to a large extent.

- Customer acceptance

  Customers are a vital link in the process to successfully implement SM systems. If customers do not experience any advantage their perception and rejection of the system can nullify any planned benefits from making a significant investment in SM. Ensure that your customers are informed and sell the customer benefits to them. The visibility of customer consumption data is of vital importance. Make it easy for customers to use and appreciate the new system.

13 Communication options

Smart Grids and Smart Metering systems are highly reliant on effective and reliable data communication systems. The requirements at the various nodes and applications also vary according to the bandwidth and latency allowed at the specific nodes. Electricity protection devices for example would require millisecond response times whereas metering devices could be read and data collected at various time slots during a day.

The establishment of utility owned communication networks versus the use of external communication service providers also need some evaluation. Third party cellular and RF spread spectrum networks may be covering the total utility area. It should thus not be necessary to duplicate this infra-structure. As far as the last mile communications are concerned the PLC and radio mesh communications could be installed and owned by the utility. Once these links have been installed it will serve the purpose of establishing dedicated communication between meters and concentrators and will have no overhead operational cost apart from maintenance. The communications between meters and concentrators are to a large extent inherently part of the offering of a particular supplier and will be part of the AMI roll-out infra-structure.

For the purpose of rolling out AMI systems the following communications media will be suitable in most cases. Combinations of these technologies will be used in SM systems. Choose the most reliable and cost efficient method for the roll out of larger metering installations. The final choice of communication medium will be dictated by physical and geographical attributes and one should allow for a combination of systems to be used in a particular area. Where radio transmission is not reliable due to building construction or interference from nearby radio transmission devices PLC may be the better choice. PLC on the other hand may be unreliable due to noise introduced on the electrical network generated by industrial devices and installations.

Technology ages very quickly and systems deployed will have to allow for the upgrade of the data communications devices used in a particular installation. Meters should have a service life of 10 to 15 years but communication and networking will change significantly during this period. An effective strategy to future proof communications assets will have to be deployed. The adoption of very stable standards are normally the only methodology to ensure that technology survives the technology development phases and provide financially viable service before it will be phased out. It is also a fact that a utility will have a combination of older and newer technologies installed in the field. These installations will have to be compatible to provide a seamless AMI system.

- Cellular (wide area)
- RF Mesh (short distance)
- PLC (short distance)
- Radio Spread Spectrum (wide area network)

- Fibre optics (dedicated WAN links)

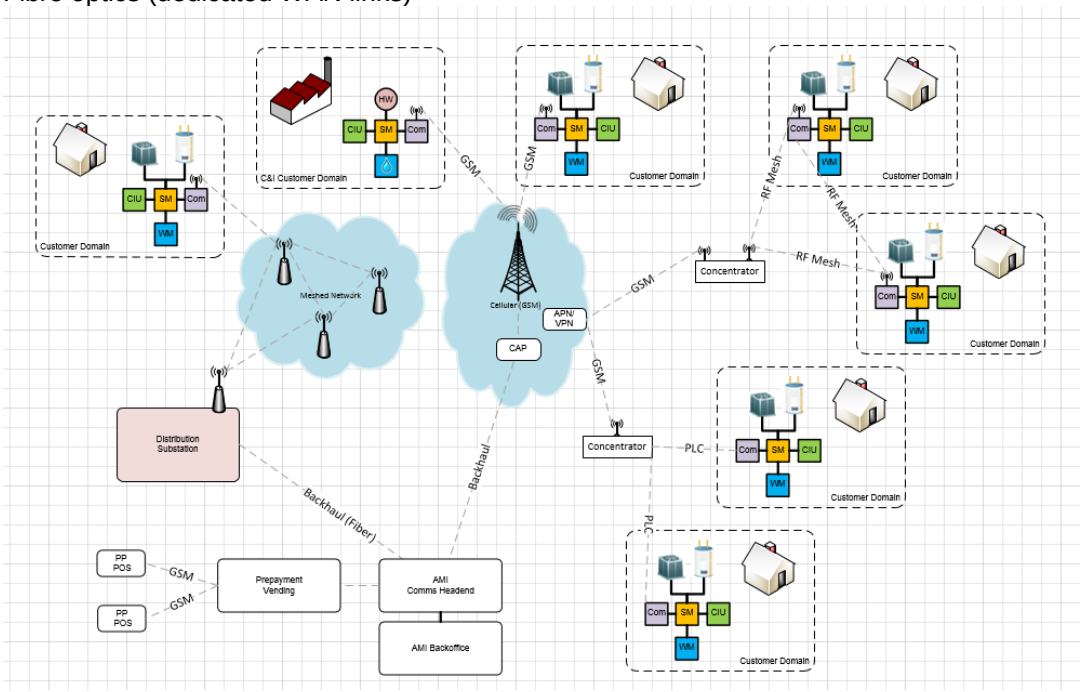

Figure 3: Communication options

14 Security

The European Network and Information Security Agency (ENISA) report *"Smart Grid Security - Recommendations for Europe and Member States"*[1] also recommends a broader context. A summary of enterprise level recommendations inlcudes:

- Consider Cyber Security and Privacy as a vital part of your system implementation
- Security efforts should not only include smart meters
- Security training of operations staff and consumers
- A set of standards and guidelines that includes (among others):
  - reference risk assessment methodology
  - methodology for assessing interdependencies
  - incident handling strategy
  - establish security governance
- Consider Cyber Security in all domains and phases of the system lifecycle

15 Conclusion

The planning and implementation of SM systems requires experience and knowledge of the systems and standards in the industry. It is also essential to select appropriate technology to ensure compatibility with future as well as existing and legacy systems. Utilities should embark on this road with caution. Compile a cost benefit analysis and ensure that the utility implement functionality where the maximum benefit can be derived for the supplier and the customer. Ensure that your staff, customers and all the utility stakeholder form part of your implementation team. The success of a SM system roll out depends on co-operation between technical, financial, ICT and management. Manage the risks, quality and functionality of the new system effectively to operationalise information to the advantage of the utility.

[1] (Smart Grid Security - Recommendations for Europe and Member States) Additional details of the recommendations is provided in Annex B.2 ENISA Recommendations.