Managing smart grid networks for improved utility operational performance

by Clifford Ntshudisane, Power-C Metering Africa

The aim of this paper is to propose principles of core requirements for the implementation of a full end-to-end turnkey, smart grid solution based on Advanced Metering Infrastructure (AMI). The paper takes into account the overall challenges municipalities/distribution companies are confronting these days, suggesting implementation of a comprehensive solution utilising smart grid applications.

A modern distribution grid, which smart metering is an integral part, allows greater control of the distribution grid, being essential for assuring the viability of municipality operation.

An advanced, multi-layer, anti-fraud protection system can provide real-time tamper prevention and control on the meter level and on the grid level, delivering full transparency of losses in the grid. Such a system provides a dramatic reduction in lost revenues and boost to revenue collection towards balancing expenses with the energy supplier (Eskom).

Despite the comparatively smaller size of municipalities in comparison to national utilities, municipalities as distribution companies for electricity and water should have access to the full scope of services available to large-scale utilities.

The adoption of a smart grid platform supports the possibilities for implementing all the current and expected future requirements of a modern grid network, including real-time anti-theft revenue protection, smart prepayment and vending, asset management, demand side management, outage management, GIS, workforce automation, customer service portals, project implementation, etc.

In this paper, solutions and capabilities of best practice discussed, includes a multi-faceted approach to ensure end-to-end loss control/revenue protection and revenue enhancement within the smart meter ecosystem.

Smart revenue protection

Energy losses

From Day 1, the foundation of any smart metering solution is the implementation of an exception alerts and alarms system (hereinafter “revenue-enhancement-intelligence”) including the MDM, smart meters, keypads and related interconnected sub-systems (e.g. Vending Management System). The “security-net-intelligence” service will minimally:

- Identify early malicious activity, and
- Proactively notify the MDM operator/administrator and field service operators.

The advanced smart metering system reduces collection losses by identifying meter and grid tampering. The hardware and software also continuously calculates energy losses and monitors un-normative consumption profiles.

The PLC data concentrator meters the output of the LV transformer and compares the total power consumption with the individual power consumption of the users in the same root. This analysis enables the system operator to identify tampering and excess line losses within this network root.

Addressing lessons learned

Specific attention should be made as it relates to critical challenges of smart metering projects implemented elsewhere in reducing commercial losses of power distribution companies:

Lesson 1: Smart meters vs. simple metering

Despite the relatively higher cost of implementing smart meters in comparison to simple prepayment meters, utilities the world over are adopting smart meters to replace existing simple pre-paid meters claiming that they are more secure and cannot be easily tampered with like pre-paid ones, insisting that it is far more secure and less susceptible to tampering by consumers. Simple prepayment meters can be a potential solution to improve poor revenue collection but they cannot provide an effective solution against electricity theft involving meter by-passing or meter tampering. In addition to an advanced metering system plus the associated meter data management offering the most effective solution to rapidly reduce commercial losses, the use of AMI is considered a “future proof” investment and regarded as a key building block for smart grid development to meet the power sector needs of tomorrow.

Lesson 2: Two-way real time solution

Provision for reliable and cost efficient bidirectional communication with the smart meter assets is essential for real-time monitoring and control. A smart meter with a modular communications system enables hot swappable, field replacement of the communications module enabling plug-and-play flexibility of any communications, such as PLC, GPRS or LAN without dismantling the meter. It provides freedom of choice to the municipality to incorporate new communications technologies that evolve and a variety of communication modules in each zone.

Lesson 3: Challenges of STS vending

Challenges have been observed relating to illegal vending of STS tokens. When a suitably “smart” metering system downloads the STS token into the meter the system should receive a confirmation from the meter through the two-way communication that the token has been successfully loaded and then reads the credit balance in the meter. This is to validate the transaction and to ensure that the meter has accepted the exact value. With every increase in the kW hour balance within the system, the system should automatically verify with the billing and vending system whether that increase is backed up by a legal transaction. The system should log all activity with the meter so that it is able to maintain records of the individual who loaded the credit whether it was performed automatically or manually, information of the user, the time of the transaction and the amount. All this information should be stored in the database and is available for managers to verify.

Lesson 4: Project performance indicators

Monitoring and evaluation of the project performance indicators should be agreed with the vendor and baselines established. A project objective should include the level of the collection rates. After the completion of the project, the parties should conduct a study, through a joint technical committee, to determine the success of the project including an economic component and financial model for the purpose of evaluating the profitability of the project. The outcome information would be useful for evaluation of longer-term prospects.
of replicating the project; and drawing lessons to improve performance in delivering service.

Lesson 5: Project financing
Since many municipalities are facing a constrained financial scenario, which impose significant challenges to the development of infrastructure projects, limited access to financial resources needed to implement smart grid programmes may be mitigated by resorting to support of private sector partners.

Lesson 6: Implementation
Implementation risks of the system should be properly mitigated. Many projects have failed, not because of the products but by faults in implementation. An end-to-end, turnkey solution provider with full responsibility of the whole scope of the project, including integration with the municipality’s back-office systems, can provide seamless delivery to design/plan, integrate and deploy with the needed flexibility and timely response to any customisation requirements towards rapidly deploying the end-to-end solution.

A well-designed and implemented customer engagement plan to engage with the customers is considered necessary for acceptance of the technology and avoidance of tampering attempts.

Efficiency of metering devices installation can be streamlined using low-cost smart hand held devices for electronically entering the devices as an asset into the system, with the GIS location enabling full transparency of the grid. Such devices also enable workforce automation by monitoring and reporting how many meters were installed per time-period. If a quality or performance issue occurs, the system can provide an audit trail.

Lesson 7: Efficient consumer engagement
Since electricity and water services is a critical system and needs 24/7 reliability, increased visibility to the customer makes life easier and provides much faster response to their needs, such as when there is a power outage or failure to load a prepayment token to the meter.

A self-service customer portal should provide the consumer with access to consumption/cost/tariff data, as well as messages from the utility, and outage information. Customer satisfaction is improved and operating costs reduced with increased customer awareness through automated notifications, such as email/SMS of low prepayment credit and outage information.

Smart grid network
Asset management
An AMI based Asset Management System (AMS) lowers operating costs, helps prevent outages, and minimises unexpected capital investments for more efficient network life cycle management – all in a single system. An AMS should feature an open architecture, web browser-based platform, which has a dynamic, and interactive user interface, and is GIS ready. With a comprehensive set of tools, the municipality can access:

- Asset view: cost-effective, deep visibility into the distribution network, such as visibility of meters connected to which transformer, and which phase. Municipalities can choose to prioritise locations in the network rather than all potential locations – an approach that yields significant cost savings while delivering high value.
- Power factor and voltage monitoring: displays actual measurements of system asset loading, voltage and power factor parameters. Values can be used for monitoring of voltage/power factor violations (above and below nominal values), load balancing, balancing the load between phases, system planning, new services and design support.
- Transformer view: Overloaded transformers are recognised by aggregating and analysing meter-by-meter AMI load data at each distribution transformer in order to prioritise them for early replacement and prevent failures. This type of early identification and proactive replacement of at-risk transformers can save a municipality in transformer failure costs. By identifying at-risk transformers with high load growth, the municipality can better size failure replacements.

Outage management
An AMI based Outage Management System (OMS) provides automated notification of outages for faster restoration time, assist in the diagnosis and analysis of the probable cause of outage, as well as automatic notification to affected consumers, while providing validation of the electrical infrastructure status for the safety of maintenance crews.

Furthermore, ensuring reliable services that the municipality provides to its citizens in a timely manner is of fundamental importance to all stakeholders. The OMS should assist in ensuring that minimum service levels are provided by accelerated and automated measuring and reporting to management, government authorities and the public.

The OMS can leverage the smart meters’ internal battery, during the absence of external power, to send a “last gasp” outage alert via remote communications to the OMS. The smart meters will remotely send all the load profile channels for the two minutes prior to the outage in order to analyse and diagnose the probable cause of outage, such as loss of phase, overload, or drop in frequency. This will provide important data in real-time to quickly detect a potential power outage event of transformer, feeder, or substations, scoping the size and location of the outage and pinpointing affected service points and for both predictive and post-incident analysis to identify likely upstream incident devices.

With availability of an OMS, realised savings will appear in substantial increase in real-time data availability, visibility of affected areas and less staff resources to manage an increasing outage workload, internal and external standards compliance, automated customer notification and resulting decrease in customer calls and ROI in a short timeframe.

Demand side management
The AMI should support intelligent elements
in the grid which gathers and analyses information in real-time in order to determine whether the grid is at risk by high demand at certain points (domestic consumer, industrial consumer, city). The system should support load control devices installed in consumer premises to limit the use of auxiliary customer equipment (hot water heaters, air conditioners, swimming pool pump, etc.) during peak energy periods. The MDMS should support under-frequency monitoring for rapid response to peak demand. The MDMS should have the option to disconnect and connect customers upon settable values in frequency. The Demand Side Management System (DSMS) should offer load management for all MV and LV consumers performing peak levelling, peak shaving and load management.

Conclusion
The introduction of smart grid technologies focused on reducing energy theft is a very effective tool to optimise the use of existing infrastructure in the electricity sector. However, careful planning and development must be administered. To help evaluate distribution efficiency projects for improving service delivery and reducing losses, consider asking the following questions:
- Is the system engineered to remotely control essential elements such as the ability to:
  - Remotely credit a meter
  - Remotely switch between credit and pre-payment
  - Send immediate online tariff changes
  - Provide emergency credit
  - Trick flow or load limiting when credit runs out
  - Provide user friendly pre-notification of disconnections
- When the meter has no power and terminal cover is opened, will the meter detect and record the event and disconnect immediately power resumes?
- Do the meters have a super-cop in addition to a battery to expand the lifetime of the meter to a minimum of 25 years?
- Can load limitation be customised for each individual consumer or groups of customers separately, i.e. select customers at automatic disconnection above 60 amps?
- Does the system cover all the requirements of a modern utility, including support for demand side management, GIS asset mapping, business intelligence, transformer load management; outage management; voltage/reactive power management, meter installation automation, etc.

Contact Clifford Ntshudisane,
Power-C Metering Africa,
Tel 011 523-3000, clifford@pcma.co.za