When is Smart Metering really smart?

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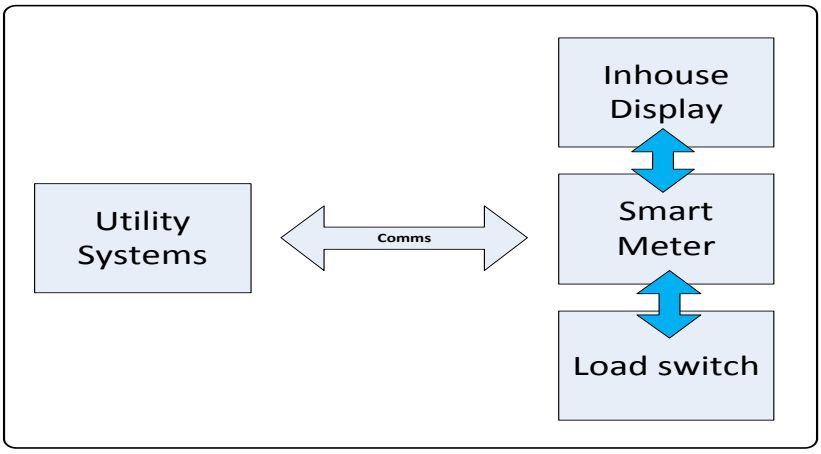
Abstract: Smart Metering (SM) systems are rolled out at a high rate internationally for various reasons. It is however true that SM as a component of Smart Grids will play a significant role in the electricity distribution industry to enhance energy efficiency and support revenue management. This paper elaborates on the functionality of SM to support various aspects of distribution management in the African context. The effective use of the data collected by a SM system as well as functionality provided by SM can be used to enhance the services and financial viability of electricity utilities.

1. Introduction

Smart Metering for the purpose of this presentation comprises of a metering/monitoring/ load switching device located at the electricity supply point to a customer premise (fig1). The devices will also enable utilities to perform much more than merely obtaining a consumption reading for billing purposes. The device and its supporting infrastructure enable utilities to effectively monitor and manage the low voltage distribution system in a network. This part of the distribution network has always been the “neglected” part of an electricity supply system due to the cost of installing SCADA (Supervisory Control And Data Acquisition) systems at this level in the system. Any feedback from this part of the network was accomplished by customer feedback and complaints as well as maintenance and meter auditing operations. Thus in most cases a reactive process.

Fig 1: Basic SM system



SM is installed internationally for various reasons and it is important to understand what the African requirements are. The following functional and management functions can be supported with appropriate technology:

a. Energy efficiency
b. Demand management
c. Maintenance management
d. Revenue management

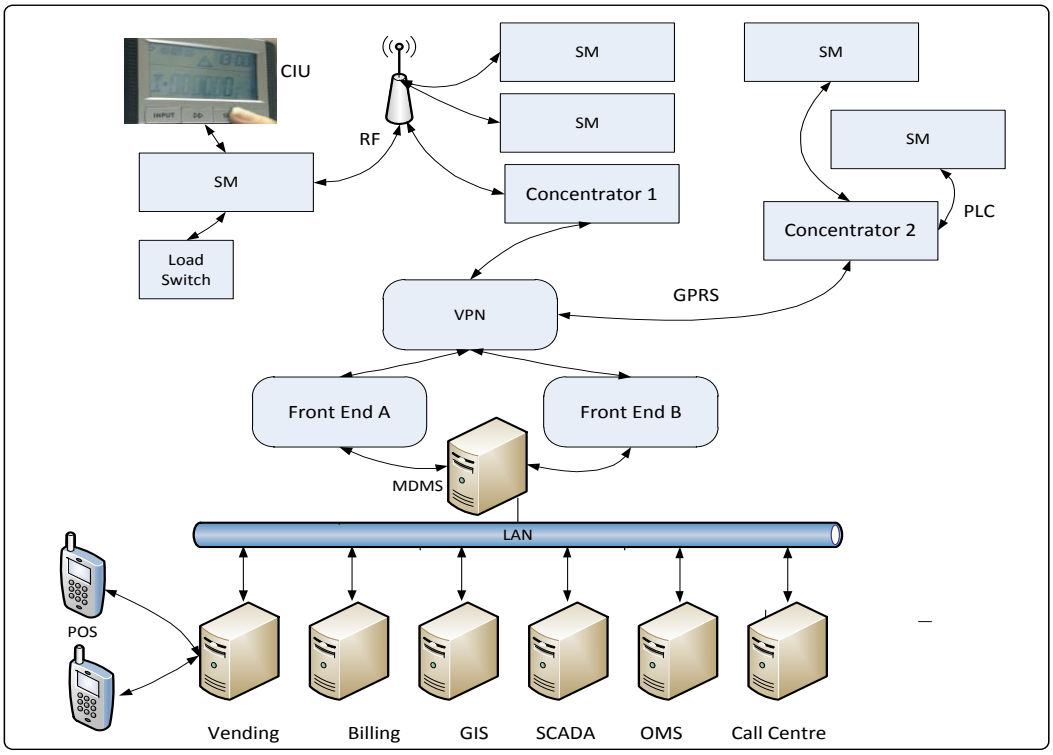
e. Revenue protection.
f. Network management

It is also necessary to future proof systems as much as possible to extend the lifespan as well as improve the financial viability by:

g. Adopting proven international standards
h. Appointing reliable meter system suppliers
i. Exploiting the advantages of the new metering system by effective integration into existing systems and processes.

This paper will thus attempt to explain the total impact of installing SM systems as a path to upgrading and improving network and utility management. A typical SM system will include functional blocks as shown in fig 2. At the customer premise a smart meter with load switch and in-house display will be installed. These devices communicate with concentrators via radio or PLC (power line communication) communication systems where the data for a group of meters are collected. The concentrator is again connected to the main controllers via cell phone, fibre optic or radio communication channels. The data is transferred to a MDMS (meter data management system) for storage and processing.

Fig 2: SM system



2. Metering system

The metering functionality of the system will collect and process the following data:

a. Automated readings
b. Interval data
c. Support complex tariffs
d. Credit/ prepayment switching
e. Automated prepayment credit token transfer

In the metering mode these systems provide the measurement and recording functions to enable effective measurement of consumption data for billing purposes. The fact that it records interval data enables the utility to determine when and where energy has been used. Half an hour profile data can be obtained to facilitate network management and enables the use of time of use tariffs.

The system will thus enable the utility to record consumption accurately as well as have access to detailed energy flow information in terms of the load profile data recorded every 30 minutes. Readings on all meters will be synchronized to enable detailed consumption information during a specific period and facilitate energy balancing in a specific area of supply.

The meters can be switched between credit mode and prepayment mode remotely. Credit tokens purchased at the vending outlets or online via the internet or cell phone will be transferred to the meter directly. The South African SM specification, NRS 049, also requires a compatibility with the STS prepayment standard to facilitate the use of existing vending infra-structure to serve the Smart Prepayment Meters. The keypad on the Customer Interface Unit (CIU, display and keyboard installed in a customer's residence) will also allow the manual entry of STS tokens when required.

The meter allows the implementation of complex tariffs. The use of TOU (Time of Use) tariffs allows the utility to offer new energy products to the customers as well a use pricing signals to manipulate the consumption pattern of consumers to enhance energy efficiency. The SM system will support improved meter readings and billing processes. Fig 3 depicts the flow of data to the various functional applications

The "smartness" thus: A flexible, multifunction metering system to enhance the management of distribution systems and improve energy efficiency.

3. Revenue management system

a. Accurate meter readings
b. Timeous billing
c. Pre-processed readings with VEE (validation, estimation and editing)
d. Remote connect/ disconnect

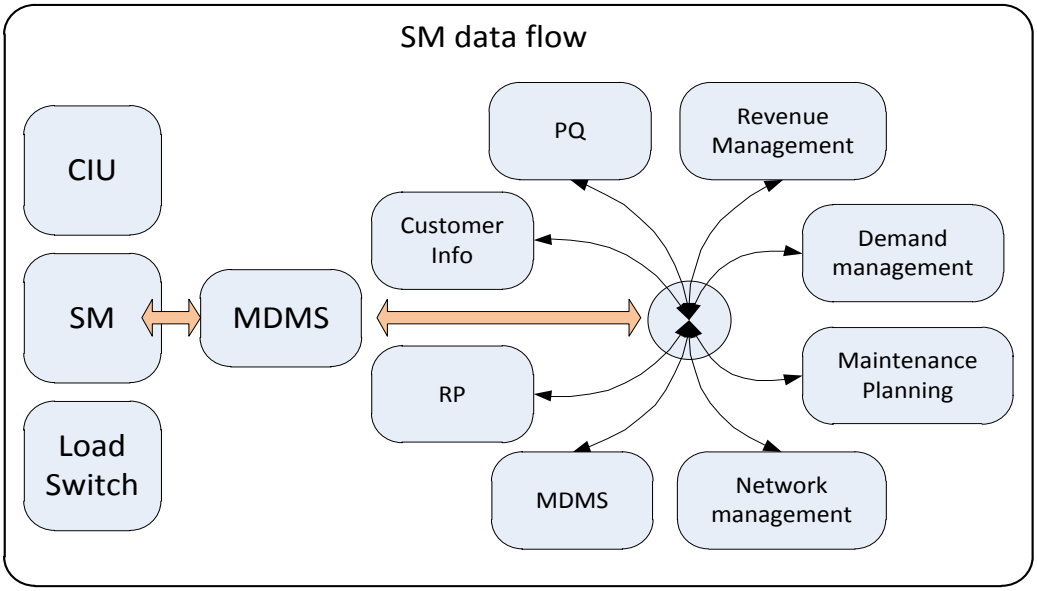
One of the most important challenges in South Africa is to read meters and produce accurate bills to enable customers to pay their dues. Meter readers are used to physically visit customer premise to read meters. It is not always possible to get access to meters resulting in "no reads" or "estimated" readings on a customer bill. Many fairly manual processes are followed to verify meter readings and bills. It is however not possible to check every single bill in detail on a monthly basis. In the case of SM the consumption data will however be validated and any inconsistencies corrected in the MDMS before it reaches the billing system, ensuring much higher quality billing. The VEE (validation, estimation and editing) functions allow the utility to effectively manage consumption levels, missing readings due to meter failure and energy theft due to bypassing of meters. The occurrence of incorrect billing will be reduced significantly.

The SM system supports functionalities like remote connection/ disconnection. It will facilitate timeous and accurate billing to ensure that customers receive correct bills. If the customer does not pay his/her bill a message can be sent to the CIU (customer interface unit) warning that payments are due. If no reaction from the customer occurs the supply can be switched of remotely. As soon as payment takes place the supply can be restored immediately. It thus improves the revenue collection process significantly by eliminating physical visits to the customer premise. The communication link to the meter thus provides the utility with the same control mechanisms as used by cell phone and telephone service companies.

Accurate meter reading and billing will restore customer confidence in the utility and improved payment will result.

The “smartness” thus: Timeous, accurate readings and billing to improve customer confidence as well as management mechanisms to improve revenue collection.

Fig 3: SM data Flow



4. RP (revenue protection) system

a. Reading VEE will detect anomalies
b. Tamper detection
c. Alarm generation
d. Energy balancing and loss detection
e. Non payment/ tamper disconnection

Most utilities employ RP officials or contract meter auditors to visit and inspect meter installations for safety and especially tampering issues. One often encounters reports of significant improvement in payment after the meter audit and claims of reduced losses. This process is fine but very time consuming. The visibility of the meter auditors also motivate customers not to tamper with meters. The main challenge is however the time and cost to maintain this visibility where required. Soon after the meter audit, customers revert back to their old tampering habits or pay “contractors” to “adjust” their metering system.

A utility requires RP officials to be at the right place at the right time. SM systems can be this “guard dog” to monitor meters 24/7. Any tampering with a meter will generate an alarm that will be forwarded to the utility MDMS (meter data management system). The VEE functionality will raise an alarm of suspicious consumption levels. Daily reports will guide the RP official to attend to immediate problems and provide a focussed, enhanced more cost effective service to the utility. The remote disconnection function can be utilized to manage tampering and non-payment cases. This will result in reduced energy losses, less tampering and more efficient personnel and supporting resource utilisation.

The “smartness” thus: Improved, less costly revenue protection operations with automated meter monitoring and alarm functionality. The end result will be significant reduction in energy losses.

5. Network management system

a. Low Voltage SCADA
b. Outage detection and management
c. Demand and Load control

Distribution utilities hardly ever deploy SCADA or monitoring systems at the low voltage level. This is mainly due to the cost of such systems. The installation of SM however requires a communication system covering the low voltage network. The meters effectively constitute a SCADA RTU (remote terminal unit), albeit with limited functionality, at the supply point and SM can also be installed at the 11kV/400V transformers. The SM system does not provide real-time information with the latency of a SCADA system but never the less provides useful information regarding the state of power at the supply point. Any failure of power will be reported and the meter stores "event" information that can be downloaded. Power quality information is also available. The SM is thus a vital component in the development of SG (smart grids).

The SM also provides load switches to control loads on the customer side of the supply point. Geysers, pool pumps and air conditioning can be included in an effective demand side management system enabling the network control centre to manage demand in critical supply situations.

The "smartness" thus: Low voltage network monitoring system with demand side management capabilities.

6. PQ monitoring system

a. Basic PQ monitoring at LV supply points
b. Voltage and interruption logging

The SM provides basic power quality monitoring at the customer supply points. This facility has never been available to utilities on the low voltage network. The only method to solve this was to use recording equipment or dedicated PQ monitoring equipment at strategic points in a network. If a customer for example complained about the voltage level, a specialized investigation had to be performed. This information is now available and high and low alarms can for example be set to record the problem periods.

The "smartness" thus: Distributed low voltage network power quality monitoring system with threshold alarm capabilities.

7. Maintenance and planning system

a. Distribution system loading and power flow
b. Faultlog system
c. PQ information
d. System loss measurement
e. Parameter trending facilities
f. Maintenance alert
g. Job scheduling
h. Meter Error detection

Analysis of the data collected from SM system can be utilized to identify maintenance actions as well as network extension and upgrade planning. The PQ and power outage information will provide a good indicator where the network need maintenance or upgrading. Meter failures can be detected immediately and the necessary maintenance and repair teams activated. These operations can now

be focussed to use personnel and other resources more efficiently. Customer service will improve due to prompt reaction to failures in the distribution network.

If SM is used to monitor each low voltage substation as well as all the customers supplied from this point, energy balancing is an automated process. Loss measurements can be used to identify technical and non–technical losses. Capital and maintenance budgets can now be based on operational information from the SM systems rather than Ad Hoc measurements in the network.

The "smartness" thus: Provides low voltage network maintenance and support information

8. Customer information system

a. Consumption feedback
b. Cost and tariff information
c. Outage warnings
d. Bill payment information
e. Remote disconnection/ reconnection
f. Prepayment options

The customer plays a vital role in the successful implementation of SM systems. As was the case in many other countries in the world, customers can either accept and utilise the SM facilities or view it as a method to "spy" on them and force them to pay for services. In many cases customers have taken the stance that the radio frequency emission of these metering systems is detrimental to their health (although everybody is using a cell phone with much higher RF emission) or in some other cases that the more detailed consumption information gathered is impeding on their privacy. Whatever the case may be, the customer should be convinced and educated to realise that the SM is providing essential and useful information.

It is thus essential that effective implementation of SM is to the advantage of the customer in terms of energy management as well as the improvement of services. The SM system opens a new communication channel to customers to inform them of the actions and intensions of the utility without reverting to call centres and the other media.

The direct information available to customers is consumption and cost feedback on the CIU. To ensure that customer respond to energy efficient signals and improve energy efficiency it is vital that a customer be given the correct timeous information. It does not help too much if a TOU tariff is implemented and the customer only sees the result of his consumption pattern on a bill two weeks after the end of the consumption month. It is thus important to directly involve the customer in the roll out of systems to show that they can save cost by using system information.

Payment notices to the customer can be a very persuasive tool to manage revenue collection. (Everybody reacts very quickly to the DSTV mail message on the screen)

The "smartness" thus: Provides the utility with a communication mechanism to keep the customer informed about energy consumption, cost as well as network operations.

9. Demand control system

a. Direct control of devices like geysers, air conditioners and pool pumps
b. Load limiting during high demand/ supply shortage crisis situations
c. Indirect load and energy efficiency control via TOU tariff structures

South Africa is also like many other African countries in a predicament that the demand for electricity is at times very close to or more than the supply capability of the generation system. Many energy efficiency and demand side management projects have been launched already. The SM system however provides two methodologies to manage the demand for electricity on the consumer side of the supply network. The first method is to provide load switching facilities that can be controlled by the utility. These switches can be utilised to disconnect the supply to non-critical appliances like air conditioners, pool pumps and hot water geysers as well as other residential loads. The metering systems can also be used to limit the supply to a customer and motivate the customer to disconnect load himself.

The second method to manage demand and promote energy efficiency is to use TOU (time of use) tariff structures to reflect the actual cost of energy at a particular moment and also send a strong price signal to the customer. By effectively using the TOU tariff a customer can reschedule certain loads and save electricity cost as well as improve energy efficiency. To implement SM without the advantages of TOU tariffs are essentially like a car without tyres, not very effective.

The “smartness” thus: Provides demand side management tools to control peak demand and improve energy efficiency

10. Data management system

SM is about data management and the extraction of information gathered with the metering system in the low voltage network. As illustrated above many benefits can be derived from the use of data in the SM system. The heart of the operation is however to install a system to manage the data, analyse data and convert this into useful management information. None of the abovementioned functionality is viable without a very effective MDMS (Meter Data Management System.) Many utilities underestimate the impact of these components in a system and collect a massive amount of useless data. Some utilities view the MDMS as a store for SM data. Although data is stored in this system the conversion to information is a major task requiring specialised software and programming tools. The functionality of the MDMS is a presentation all by itself but includes the following items:

a. Consumption data store
b. Alarm processing
c. Billing data pre-processing
d. Installation data storage
e. Tariff management
f. PQ reporting
g. VEE function
h. Reporting and analysis
i. Tamper reporting
j. Energy balancing
k. Unified interfacing to existing systems from multiple metering technologies
l. Prepayment token management
m. Planning and maintenance data input
n. Power quality analysis
o. GIS source data
p. On demand reading processing

The “smartness” thus: MDMS to convert raw meter readings and related data into useful management and operational information.

11. Success factors to implement SM

a. Be very specific as to what should be accomplished
b. Involve all role-players from engineering to finance
c. Do not under estimate the customer's role on the successful implementation
d. Adapt business process to maximize benefits to be derived from a SM system
e. Use only proven technology and standards.

12. Conclusion

a. SM certainly has a place in African utilities.
b. Utilities should exploit the full range of functionality of SM systems.
c. Do not implement glorified metering systems.
d. Carefully integrate SM into your distribution management systems and adapt business processes.
e. Ensure that a specialized MDMS is implemented with the SM system to ensure that the collected data is effectively analysed and benefits derived from the total system.
f. Remember SM is not a metering system but a new way of managing your distribution system more effectively.
g. **SM is only really smart** if the collected data and related data from the systems are used effectively to improve and adapt business processes, utility operations, management and customer services.