BUILDING A REAL SMART SOLUTION

LEADING THE ELECTRICITY DISTRIBUTION INDUSTRY

AMEU

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Synopsis

Introduction

Post the 2008 world financial crisis the rules have changed. Many countries are still coming to terms with the sudden and debilitating financial crisis. Some governments have been able to stave off the world recession by pouring reserve funds into public works programmes, but these coffers are now empty.

It is within this context that we have seen the rapid adoption and deployment of revenue protection and management systems globally. In particular we have witnessed the exponential increase in STS (Standard Transfer Specification) IEC62055-41 projects in many emerging markets.

The increased popularity of STS can be seen by the number of companies (many international) who are becoming active members of the STS Association, the body responsible for the governance of the specification.

In addition to the financial crisis there is growing concern over our environmental health, including the sustainability worries over our global energy resources. There is a palpable change in the consumption habits of our world's population. This however has been predominantly in the affluent (dare I say) first world economies. In many of our emerging markets the general population are lower down on Maslow's hierarchy of needs. The supply of basic resources and services for these customers is less than guaranteed.

These two global crises have caused a substantial shift in project funding, leading to a massive switch to service supply projects that are aimed at efficiency and appropriate utilisation of resources.

The momentum to "Smart Solutions", whether meter or grid, has raised as many questions as it has answered.

It is within this seemingly confusing context that we have determined the pressing need for a system that is both financially sustainable and functionally appropriate.

The customer

Putting the proposed system into context, it is necessary to expound on our target market. The majority of our customers will consume less than 7kWh/day. Comparing this with a European daily average of 18kWh/day or the USA average of 39kWh/day one can see that the introduction of an expensive Smart metering technology into this business case is financially not viable.

There are some rural communities that use an average of less than 2.4kWh/day. It is patently clear that any solution for these customers needs to be substantially different to that deployed in Europe and the USA.

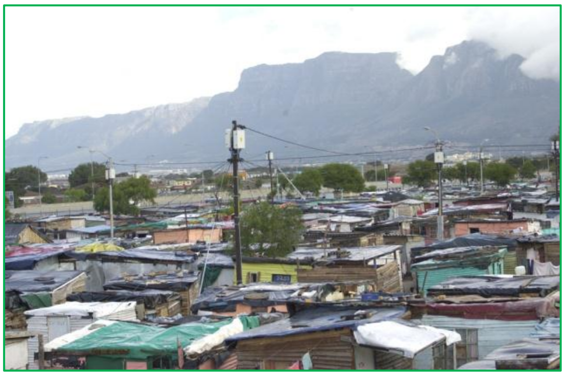

Figure 1 : Our typical customer profile

The real smart solution

The proposed solution is a radical departure from those that have gained such notoriety to date. Virtually every magazine and conference targeting Electrification programmes or the Electricity Utility market has at least one article on smart grid / smart metering applications. The global market is saturated with the hype associated with Smart metering and the benefits and concerns over this technology.

One of our most prominent system drivers when defining the architecture of a smart metering system was the adoption of a sustainable prepayment revenue management model that will see the capital investment being redeemed within a few years.

Advocates of the first world smart metering and smart grid systems would argue that including the element of prepayment in these systems is an unnecessary overhead and adds complexity. However, as will be detailed, the inclusion of prepayment into the system builds in a redundancy and a flexibility that is both appropriate and convenient for the Utility and customers alike.

The proposed smart solution does not compete directly with the “first world” (high consumption consumers) smart grid / smart metering systems, but rather is a bottom up approach that is appropriate for both low consumption and high consumption consumers using field proven prepayment metering building blocks. The solution is both modular and extensible.

In the conventional smart grid / smart metering systems the cost per point of supply is typically several thousand Rand. The business case for such a system to be rolled out to low end electricity consumers just does not give the Utility any return on investment (ROI). In South Africa it was to be legislated that consumers that consume in excess of 1,000kWh per month should have a smart meter installed in their premise. Our question is, why limit the technology to the high end consumers, why not deploy a solution that benefits all consumers (while being financially viable).

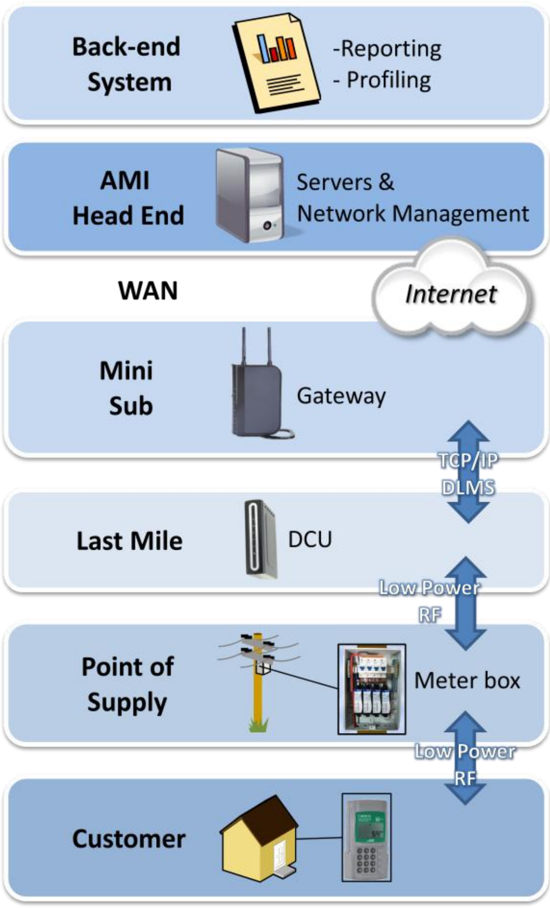

Figure 2 : Basic system architecture

The above graphic is a system view of the alternative smart metering / AMI capable system that meets the basic requirements of the Utility while still being affordable and expandable to the entire market. It is a compromise between functionality and affordability while being inherently expandable.

Keeping everyone talking

Fundamental to the solution is the element of interconnectivity between different systems. It is imperative that standard protocols and norms are used between communications nodes. One such protocol is the DLMS / COSEM (Device Language Message Language) which has been adopted internationally in many smart metering applications.

System elements

Using the diagram of Figure 2 each system element will be discussed in detail. The system can be deployed in a phased manner to accomplish a functional smart metering / AMI system. The proposed system uses the humble prepayment meter and in some circumstances even the previously installed meters can be enhanced to offer remote metering functionality.

Many smart metering systems utilise GSM modems in each and every meter. Our practical experience has shown this to be logistical nightmare with increased operational costs being attributed to the management of the assets and the operational charges associated with the network connectivity and maintenance.

There has been some controversy and bad press regarding the application of radio frequency for last mile communications to the meter. It has to be noted that the meters in question used either GSM communications or Zigbee communications technology. Our own research and development have shown that these technologies, while being inherently robust, open (from a standards perspective), and offering adequate range have done so at the expense of higher transmission powers. The system proposed uses the same power transmitted by your humble gate / garage opener or car remote.

There are some detractors that advocate the adoption of a purely on-line type AMI system. Many of these players operate in a first world developed environment where communications network coverage and speed are taken for granted. These systems often fail in the developing nation environment where network stability is not guaranteed. With the merging of AMI and prepayment systems there is an element of redundancy afforded by the combination system.

When the communications network is down for any length of time, the customers can still top up their credit using standard prepayment electricity tokens.

The financial model of prepayment facilitates funding of often neglected disciplines of maintenance and seed funding for network expansion. It uses the common banking principles of gearing that ensure continual system enhancement and upgrading.

The premises

Fundamental to the system architecture is the concept of separating the consumer’s interface and the metering unit (commonly known as split metering).

Figure 3 : Customer User Interface

This configuration has become a norm, at least in the international markets, showing increased revenue protection and a deterrent against tampering. [Customers have a propensity to become very possessive about their integrated (meter and customer interface) unit when they have attempted to bypass the unit.] Under these circumstances the customer is seldom found at home when the Utility comes to visit.

It has been our experience that the banks are very keen to assist with financing these projects because they can identify completely with the financial model. Where things get tense is where funds have to be switched from country to country, where both financial and political stability of countries may be less than guaranteed.

The point of supply

The smart metering unit is mounted at the point of supply and is often pole mounted, or mounted in a street kiosk.

Figure 4 : Measurement and control unit

In many of the targeted markets there are additional challenges to be faced. Reticulation networks are often overloaded or have not kept pace with the expansion of the network, leading to excessive voltage fluctuations and network instability. In many first world environments the quality of supply is taken for granted, whereas in our environment the voltage fluctuations can be as extreme as +/-50% from the nominal voltage. To exasperate an already harsh environment the cabling is regularly under-rated for the continual load, most commonly because the cables are aluminium and the rule of thumb 1.6 times copper rule has not been applied. (A $10mm^2$ copper cable can operate continuously at 60 amperes. An aluminium cable with similar capacity should be $16mm^2$ [1.6 * 10mm2]).

Figure 5 : Typical pole mounted installation

International certification requirements do not specify these voltage extremes and therefore many smart metering products have difficulty operating in these environments.

Associated with the increased technical diversity required are new installation techniques and requirements. A basic understanding of the associated technologies being deployed is often advantageous to ensure optimal and reliable system operation. Stories abound of the most horrendous installations that advertise the installation contractor's ignorance of the technical requirements.

While this may seem rather alarmist, it is wisdom that has been learned in the school of hard knocks. Requirements borne out of these extreme environments include;

- The sensing of terminal temperature (to avoid irreparably damaging the product due to under rated cabling, poor termination and incorrect wiring).
- Extreme voltage capability. The normal certification standards require products to operate over a dynamic range of -20% and +15% of nominal voltage. Real world requirements in many of the developing countries would indicate +/- 40% to be a basic minimum requirement.
- Delaying reconnecting the customer's load after a power outage (using a random delayed reconnection algorithm) to reduce the network inrush currents, particularly at the feeder transformers.
- Monitoring both the consumer's power and current usage (STS only stipulates disconnection on an over power condition). As previously highlighted, with poor reticulation voltage control over current conditions can persist with extreme under voltage.

The last mile network

This is the bridge between a standalone metering system and the ability to be remote connected. It is also a critically important element where all the accumulated data is concentrated and communicated upstream to the head end system using whatever communications medium available.

The data concentrator may utilise GSM technology, but this is not mandatory, there are many options associated with the choice of the communications technology in the back haul system. Piggybacking on an existing SCADA system is just one of many alternate communications backbones that are used to keep the operational costs to a minimum.

Suffice to say that it is also imperative to ensure that there are system redundancies to ensure that data integrity and availability are not compromised.

Network communications can be either scheduled or event driven, the majority being scheduled with regular meter information reading. Event driven communications will occur only when predefined trigger points are registered, such as tamper detection or low credit enunciation.

With the system's two-way connectivity comes the ability to add functionality that assists the Utility in the management of their reticulation system. Such functionality includes;

- Remote meter reading (of registers and status)
- Remote customer management with remote connection and disconnection.
- Energy balancing
- Customer consumption profiling, assisting with network capacity planning and management
- Demand side load management, whether scheduled or unscheduled (such as when a bulk feeder goes down).

The simplicity of the solution means the infrastructure can be rolled out a little at a time, wireless prepayment meters first, using a handheld remote data capture / interrogation unit for remote data collection, thereafter expanding the system with the installation of data concentrator units (DCU) with a head end system that manages both the network and the data.

The system can be further expanded with the use of Smartswitches, these being load switches in the customer's residence. The Smartswitches control household geysers, pool pumps, under floor heating elements, air conditioners and the like.

The head end

The head end comprises a suite of enterprise applications that afford the Utility functionality on several levels. Central to this architecture is the databases that contain all the collated meter information as well as network (both reticulation and AMI communication) operational parameters.

There are typically three primary players that interact with the meter data management system (MDMS);

- Commercial, who have a vested interest in the revenue management aspects and the sustainability of the system and the business intelligence (BI) and report functions relating the customer information and billing.
- Operations, are interested in the information emanating from the system operation such as load balancing, voltage and frequency monitoring, rudimentary quality of supply information and demand side load management.
- Network administration, the division responsible for the maintenance and communications aspects of the system, including asset management.

The phased approach

The simplicity of this architecture is that the project funding can be allocated in a phased manner. With the deployment of each phase the existing capital investment is secure, it does not need to be removed or made obsolete, it is simply extended to the next phase of functionality as and when required.

It is fundamental to our approach that every stage of the system development adds to and enhances the current investment. Only rarely is it necessary to remove or upgrade installed equipment.

Important notes

An operational challenge that is often overlooked or underestimated is that of the technical competence of the personnel servicing the AMI systems. The installer's or technician's capabilities are more suitably coupled with that of conventional metering and network maintenance. They are now called upon to have extended skills in wireless, power line communications (PLC), computers, communications networks and more, often (critically) without the necessary training. This is a recipe for unnecessary problems and customer inconvenience.

No discussion on AMI / smart metering would be complete without mentioning the concerns that have been raised regarding the right to privacy and the management of data gathered regarding the customer's electricity consumption habits. With the system proposed the granularity of the information gathered will be much lower that the equivalent European or American devices. This granularity still affords the Utility the ability to monitor trends, plan network capacity. It is not within the scope of this paper to discuss the legitimacy or otherwise of the arguments. Suffice to say that the debates will continue.

A positive side effect of the implementation of such an AMI / smart metering system is the active asset management and traceability that is a natural outcome of the connectivity.

CONCLUSION

The approach tabled in this paper affords the Utility / Supply authority a way of future proofing their system with the sound financial model that makes so many of the world's prepayment electricity metering projects the success they are. The model is both affordable and sustainable.

The solution, using the humble prepayment meter associated with the required network infrastructure and head end software, offers an appropriate and financially sustainable AMI system for low consumption customers. Though the system may not have the high end functionality of a European or American Smart grid system, it affords the Utility a system that is extensible, affordable and appropriate.

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