Electrical Metering Technology Options in the Municipal Environment

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Abstract

An overview of available metering technology is offered, providing the main features of each. Further, the benefits of utilising these metering technology options in a municipal environment are sketched. This then provides a platform from which conclusions can be drawn.

1. Introduction

According to a CSIR/cidb Discussion Document: "Towards a framework for the maintenance of municipal infrastructure: In support of government growth objectives", prepared in August 2006, municipalities collectively account for 43% of the total volume of electricity sales, while Eskom supplies the balance. Few municipalities other than those in the larger urban areas, generate electricity themselves and these municipalities would usually be responsible for the transformers, the below-ground (and sometimes above-ground) cables and the metering systems for electricity distribution. The discussion paper further suggests that the following issues are responsible for non performance:

- Inadequate budgets for maintenance and upgrade of infrastructure
- Inadequate skills

The purpose of this paper is to look at available electricity metering technologies, to ensure that funds spent on maintenance and infrastructure upgrade, related to metering, are directed at both appropriate and cost effective solutions. Addressing the other issues is beyond the scope of this paper.

2. Metering technologies

In the NRS057 document, a clear distinction is made between "meter" and "metering equipment" The "meter" is defined as a device employed to measure and totalise the variable consumption of a electricity, whereas the "metering equipment refers to all components, including the meter making up the metering installation. In the electric energy environment high importance must be given to measurement methods and recording and storage devices for electrical consumption data.

The NRS 057 clearly identifies minimum standards pertaining to the meter accuracies required based on nominal size of load, highlighted in table 1.

Load	Accuracy Class			
	Active energy meter	Active energy meter	Current transformer	Voltage transformer
> 100 MVA	0.2S	1	0.2	0.2
10 – 100 MVA	0.5S	2	0.2	0.2
1 – 10 MVA	1	2	0.5	0.5
100kVA – 1 MVA	1	3	0.5	0.5
< 100kVA and whole current	2	3	1	-

Table 1: Minimum requires for metering installations

2.1 Interval and time-of-use metering systems

Interval and time-of-use meters (credit meters) are traditionally installed to measure commercial and industrial customers (Large Power Users), which are defined as consumers of electrical energy with a nominal load of in excess of 100kVA, depending on the utility. These meters have evolved with the advent of solid state technology, offering a wide range of possibilities, allowing them to be included as part of a complex metering system. These meters also introduce additional services, which were not available during the era of electro-mechanical metering systems. These services are available to benefit utilities and consumers alike.

i) Load Profile

Load profile is a record of time stamped consumption data every integration period (currently 30 minutes in South Africa). The study of this information allows for the analysis and the definition of a "customer's consumption pattern", on which various billing algorithms may be proposed.

Furthermore, load profile data supplies information about the loading of the electric system and the forecast of the energy request, therefore it is a possible to schedule load profiles as an energy function of the losses and the availability of the primary sources in the production centres.

ii) TOU (Time of Use)

Time of Use tariffs take into account define time slots or integration periods, each of 30 minute duration during the day; days during a month using holidays, workdays and weekends; months constituting the winter or in summer seasons. Modelling the outcome of applying alternative TOU tariffs is only possible with the availability of load profile data.

iii) Monitoring and Service Interruption

Monitoring allows for optimum management of distribution networks, with consequent reduction of losses in line and service interruptions. Real time recording of number of instance and duration of electrical service breakdowns can help to value the supply quality in the various areas. This information, with load profile data, provides a very good tool to evaluate the quality of supply services proposed and the real needs of the customer. So it can help the utility to know the site and the cause of the problem before sending service teams to fix it. The optimum management of the whole electric system influences the final consumer.

iv) Interface with the SCADA and Control Systems

The electric parameters measured by the meter can be added incorporated in the SCADA (Supervisory Control and Data Acquisition) or control systems. These measurements may be actual measured quantities, weighted pulses or parameter status indications. These control systems are used on the electrical grid to make control and forecasts of load demand, and assist in energy costs of the consumer.

v) AMR systems

Automatic meter reading, or AMR, is the technology of automatically collecting consumption, diagnostic, and status data from energy metering devices and transferring that data to a central database for billing, troubleshooting, and analyzing.

AMR technology saves utilities the expense of periodic trips to each physical location to read a meter. Another advantage is billing can be based on near real time consumption rather than on estimates based on previous or predicted consumption. This timely information coupled with analysis, can help both utility providers and customers better control the use and production of electric energy, gas usage, or water consumption.

Electronic meters use a range of communication options including; Low Power Radio, PLC (Power Line Communication), GSM, GPRS, Bluetooth, IrDA, RS232, RS-485 and Ethernet. AMR systems, which include protocol interpretation, processes this time stamped load profile data along with the tariff structure to formulate the billing information. The processed data may also assist with load studies and planning purposes.

AMR Hosting is a back-office solution which allows a user or utility to track the electricity consumption over the Internet. All data collected is stored in a centralized database by high-end data acquisition software. The user can view the data via a secure web application, and can analyze the data using various online analysis tools. The user can easily chart load profiles, analyze tariff components, and verify the utility bill.

Providing customers with added services to manage electricity consumption is highlighted in an address delivered by the Executive Major of Ekurhuleni Metropolitan Municipality, Clr Ntombi Mekgwe, at the Ordinary Council Meeting in Germiston on 23 September, the following related to the metering system was said: “With regards to electricity related revenue income, internet based metering will be extended from the current 3 000 or so customers, to include every demand for meters in the City, with this project aimed for completion by December 2009. This will not only improve revenue, but also ensure a world class service to our larger customers. Meter data will be available on the internet, updated at 30 minute intervals and fully accessible to the account holder or their agent. The web page includes tools that will practically assist customers to reduce consumption with visible indication on an easy to use, energy dashboard.”

2.2 Prepayment

The standard business model of electricity retailing involves the electricity utility billing the customer for the amount of energy used in the previous month or consumption period. In some countries, where non payment takes place, the utility may install a prepayment meter to reduce the non payment for services. This requires the customer to make advance payment before electricity can be used. If the available credit is exhausted then the supply of electricity is cut off by a relay.

The meter essentially consists of a software controlled unit, allowing the customer control of the electricity consumption, and offering a visible indication inside the residence (or small business) of the actual consumption and the number of units (credits) left inside the meter. In South Africa as with many other developing economies, prepayment meters are recharged by entering a unique, encoded twenty digit number using a keypad. This makes the tokens, essentially a slip of paper, very cheap to produce. The Standard Transfer Specification (STS) Association promotes a common standard for prepayment metering systems across all manufacturers.

2.3 Advance Metering Infrastructure

The “smart meter” is just one of the components of an advanced metering infrastructure (AMI) system. Smart meters may be part of a smart grid, but alone do not constitute a smart grid. The installed base of smart meters in Europe at the end of 2008 was about 39 million units, according to analyst firm Berg Insight.

The development of advanced metering infrastructure system, have borrowed from Interval and Demand technologies, AMR system technologies and Prepayment technologies. This has resulted in the advanced metering infrastructure (AMI) becoming the measuring function in the smart grid system. It provides the information about energy usage (demand) to utilities, consumers and the grid itself. This enables all parties to make better decisions about reducing costs and strain on the grid during times of peak demand. The necessary information about demand is coupled along with the energy distribution itself.

Broadly speaking, the three components: smart meters, communication infrastructure and master station, form the infrastructure needed to provide AMI services. The NRS 049 standard, details the AMI system components, which include:

- AMI master station from where the configuration and functionality of the system are controlled
- Communication network and infrastructure
- AMI or smart meters
- Load switch (disconnect/reconnect/load limiting)
- Load control devices
- Customer interface unit
- optional interfaces to communicate with a mobile customer interface

The NRS 049 illustrates two typical arrangements of AMI systems, one utilizing direct communication to the meter, and another utilizing a concentrator. The later is indicated in figure 1.

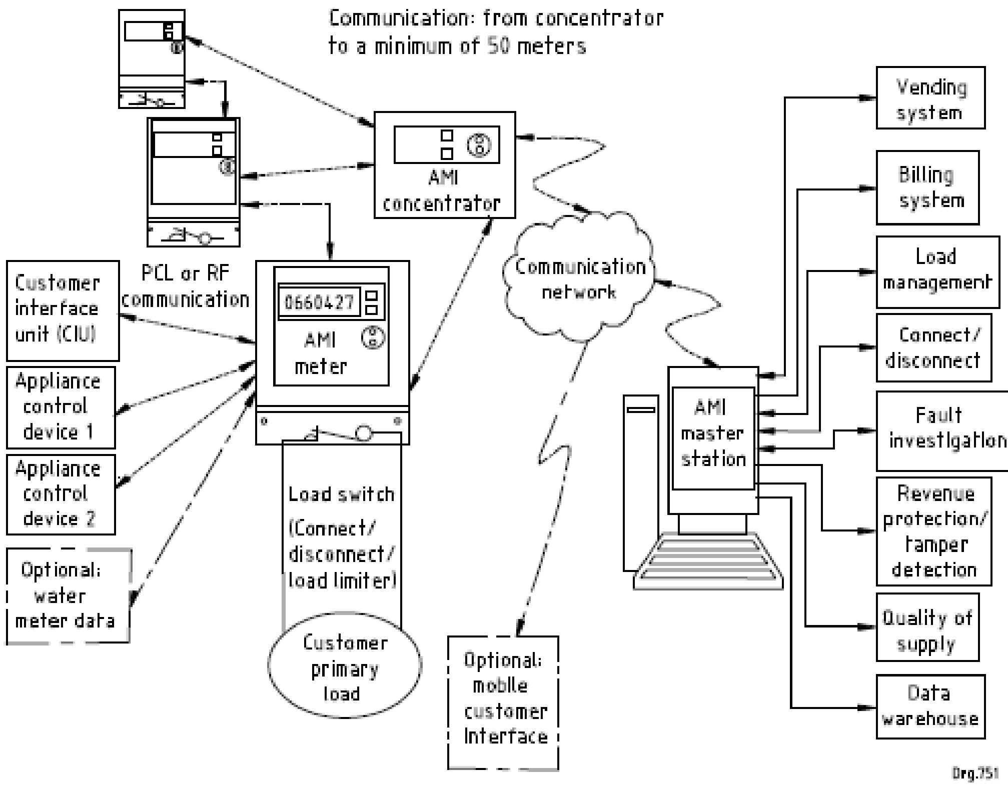

Figure 2 — Illustration of a typical AMI utilizing a concentrator

The most notable functionality of the AMI systems includes:

i) Monitoring and recording of demand

An AMI system enables a number of services related to demand measurement and billing. Meters supporting automatic meter reading (AMR) can report demand to utilities automatically via communication networks.

ii) Logging of power relevant events

Real time recording of number of instance and duration of electrical service breakdowns can help to value the supply quality in the various areas. This information, with load profile data, provides a very good tool to evaluate the quality of supply services proposed and the real needs of the customer. So AMI can help the utility to know the site and the cause of the problem before sending service teams to fix it.

iii) Anti-tamper measures

Beyond new interactions with customers and the grid, smart meters bring along new anti-tamper measures. Previous meter tamper detection mechanisms were limited to locks and tamper-evident seals. While these measures are often sufficient for keeping honest people honest, they offer little to deter malicious tampering, and can be circumvented.

Beyond physical tamper detection mechanisms, smart meters may be configured to log events concerning command history and conditions in the meters environment. This includes the detection of events indicative of physical tampering. One such mechanism, outage notification, records periods during which voltage has dropped or been removed from the meter's sensors. Reverse energy flow, may also be detected through meter firmware.

iv) Remote Disconnect/Reconnect

Utilities can disconnect and reconnect the service without fieldwork. This is especially important in areas where frequent contract changes and frequent payment delays are verified. So in real-time a remote command can disconnect a supply, for example in the case of abnormal use. In this way the work of the service staff is simplified and the repair time is reduced, the work is also less expensive which advantages the utility, and offers faster service for the user.

v) Load Control

The Demand Side Management (DSM) load control can be managed by a fixed algorithm operating independently, or by real-time control from the central station. In the later, the meters receive control messages to perform various load control functions from the master station.

vi) Switch between credit and prepayment

In non-homogeneous customer bases, the need for both credit and prepayment options may be required. The supporting systems allow for both these models to be used, and the ease of switching between them is deemed important. In the case of the prepayment model, applicable standards such as STS must be implemented, allowing existing prepayment infrastructure to be utilised, and not duplicated.

3. Deciding which technology to be used when

Much has be written and said related to which technology is appropriate for which application. In an attempt to not add to the mass of information available, some of the benefits highlighted, allowing conclusions to be drawn, serving as guidelines to decision making.

3.1 Interval and time-of-use meters

Implementing an interval and time-of-use meter requires little infrastructure to obtain benefit from it. The range of installations which may be metered by Interval and time-of-use meters include the complete spectrum of installations, from residential to transmission and generation metering. In order to capitalise on the benefits of the meters, AMR systems could be used in conjunction with the meters. Automated Meter Reading (AMR) systems, which offer less functionality than AMI system, do however enable the utility to reduce its meter reading costs and increase meter reading accuracy. AMR systems also offer the possibility of enabling some form of dynamic pricing for the customers who would voluntarily choose that approach.

3.2 Prepayment

The South African electricity consumer understands and accepts prepayment metering systems. The financial viability of the electricity distribution industry depends on the deployment of appropriate and cost-effective technology for the low consumption customer.

The use of prepayment technology ensures the eradication of meter reading errors, or those errors associated with estimations of meter readings, as meters are read. Additional fees for disconnections or reconnections due to late payment being applicable are not applicable with prepayment systems, as disconnections and reconnection is an inherent feature of the system.

Customers are able to manage electricity consumption much more careful and may even allow the credit on the meter to run out. Once income is obtained, additional credits may be purchased without facing repercussions at a later stage. Prepayment electricity is neither more expensive nor less expensive than any other form in which electricity is supplied.

Once the meter is installed, there is no need for meter readers to access your property of the tenant, and tenants are still entitled to free allocations, where this is applicable.

3.3 Advance Metering Infrastructure

i) System Operation Benefits

The operation benefits are primarily associated with the reduction in meter reads and associated management and administrative support. The increased meter reading accuracy, improved utility asset management, easier energy theft detection, and easier outage management are further operational benefits.

ii) Customer Service Benefits

The customer service benefits are primarily associated with early detection of meter failures, billing accuracy improvements, faster service restoration, flexible billing cycles, providing a variety of time-based rate options to customers, and creating customer energy profiles for targeting Energy Efficiency/Demand Response programs.

iii) Financial Benefits

The financial benefits accrue to the utility from reduced equipment and equipment maintenance costs, reduced support expenses, faster restoration and shorter outages, and improvements in inventory management.

iv) Additional Benefits

As previously described, when operating the smart meter in prepaid mode, additional benefits are in the form of those described with the prepayment metering systems.

4. Conclusion

It is important to note utilities have a range of technologies and configurations from which to choose in order to reduce the costs of operating their distribution systems and improve communication with customer meters. Each of the technologies described are best suited to specific applications and intended system outcomes.

In all AMI and AMR systems, one critical technological challenge is communication. Each meter must be able to reliably and securely communicate the information collected to some central location. Considering the varying environments and locations where meters are found, that could be a difficult challenge. In this case, prepayment meters are credit meters without AMR support are best suited. These installations tend to be rural with low average consumption.

In urban areas, the communication infrastructure is better developed, and thus less challenging to implement system requiring reliable and secure communication. AMI systems offer the flexibility of both credit and prepayment modes, with the added benefits of load control, customer management and on-line tamper functionality. This does however not mean that prepayment systems are no longer a viable solution, rather a supplementary technology which is able to be rolled out at low cost.

Interval and time-of-use metering with supporting AMR systems, are by virtue of their design, well suited to installations where the cost of communication infrastructure is small with respect to the value of electricity consumption metered, typically large power users. Service providers may be commissioned to manage the AMR systems, allowing the utility to obtain the data, without the overhead of an IT system.

List of references

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