This is expected to represent substantial revenue growth in the electricity meter market, as each smart meter unit is significantly more expensive than traditional credit, electro-mechanical and prepaid meters. Will this imminent legal commitment by utilities towards implementing smart metering systems yield the benefits they were intended for and will they help to protect the revenue collection of these Utilities?

The capability and technological growth of electricity metering over the past two decades in South Africa has been remarkable. The main areas of growth have been into electronic metering for both single-phase and three-phase consumers and well as the incorporation of advanced communication capabilities on these meters. These technology changes have enabled the expansion of the meter reading and billing dimensions available to utilities from manual meter reading to automated meter reading systems. One aspect that needs to be addressed involves the applicability of the new technologies. Is the relative increase in hardware costs providing a suitable return on investment by means of lower electricity input costs and higher revenue collections?

Technology growth

Fig. 1 illustrates the placing of the various technology trends in terms of functionality and the technology they are based on. Automated metering infrastructure (AMI) rightly provides the culmination of functionality and technologies. In South Africa, AMI systems enable the following:

- Bi-directional communications from central server to meters and devices and from these devices back to the central server
- Customers are able to have a portable customer interface unit in their premises that can read information off a meter and receive information from the utility
- Be able to control up to two relays for load control (such as hot water cylinder and a swimming pool)
- Be capable of remote load disconnect for revenue protection of the utility.

AMI hardware provides a strong and dynamic technological platform on which utilities can handle their customers according to either a credit or pre-payment philosophy without needing to change the field instrumentation. Utilities can switch between these two modes of revenue collection without having to change the metering hardware. Similarly, the hardware is independent of the electricity tariff structure and rates.

Credit revenue platforms

In terms of credit metering, the growth in capability is illustrated in Fig. 2.

Manual meter reading (MMR) systems are based on the manual collection of billing information by meter reading personnel on a set period basis. In instances where meters are not physically read each month, monthly consumption averages is used. In certain instances, end-use consumers and customers are able to read the meters themselves and forward this information either telephonically or electronically to the utility.

Remote meter reading (RMR) systems utilise the communication capabilities of the meter in order to manually collect the billing information from a centralised master station or server. Typically cellular networks are used to communicate with the meters. Most often the proprietary software of the metering manufacturer is used to enable the RMR. RMR systems also provide remote access to the configuration of the meters which allows personnel to remotely verify the meter setup.

Automated meter reading (AMR) systems, like RMR, utilise the communication capabilities of the meter to automatically collect the billing information from a centralised master station or server. In this instance however, load profile information is also typically collected and a single software platform is deployed that is capable of implementing the protocols of a range of electricity meters from various manufacturers. The software platform is not hardware specific or bound. In
advanced AMR systems, consumers have the capability of accessing their own load profile and billing data via a web-based front end. Collected data is stored in the master station and from there it can be accessed by a wider audience comprising both customers and technical personnel.

Advanced metering infrastructure (AMI) systems, as discussed, provide all of the functionality of AMR systems with the exception that the metering is capable of disconnecting the electricity supply of an end-user or consumer in the event of non-payment, can operate in either credit or pre-payment modes, can communicate and alert the master control station in the event of tampering and includes a platform with which to communicate with the end-user or customer. There is an added dimension of direct load control of appliances installed in the customer’s premises.

Simple investment decision

Investing in new metering systems will always need to be carefully considered. One method of determining this would be to consider the return on net assets (RONA). RONA is a measure of the financial performance of the utility based on the usage of their fixed assets. RONA is defined as follows:

\[
\text{RONA} = \frac{\text{Net Income}}{\text{Fixed assets + net working capital}}
\]

where, net working capital (NWC) is defined as:

\[
\text{NWC} = \text{Stock} + \text{debtors} + \text{[creditors]}
\]

Based on this definition, the investment into an upgraded or advanced metering system will be viable if the RONA of the utility remains the same (or is improved). For this to happen, the following should be considered:

Fixed assets will increase. Although some of the existing metering assets will be replaced and will essentially be removed off the asset list, the new technology will add greater assets than those that are removed. A factor of consideration here will also be the age of the current metering assets as very old equipment will have very low financial or book value due to depreciation.

Debtors should decrease as a result of alternative technologies and the ability for the utility to automatically and remotely disconnect end-use customers in arrears.

The net income of utility could realistically be expected to increase because the tampering and energy balance capabilities of AMI systems will ensure that illegal reconnections are monitored and automatically reported and the non-technical energy losses are lowered. The active management of non-technical losses via energy balances and other initiatives will help to increase revenue collection and net income against existing output costs. On the other hand, the new metering system may be more complex to operate and maintain and may increase the operational costs of the utility. This will lower the realistic growth in the net income.

In summary then, the increase in fixed assets should be matched by a combination in the decrease in debtors and an increase in the net working capital over the useful life and depreciation of the new metering asset in order to achieve RONA balance. Bear in mind that the deployment of an AMI system will have higher initial returns in terms of lower debtors and increased net income but as the deployment of this technology matures, these will taper off relative to the starting year. This is illustrated by way of a simple example in Table 1, where the relative RONA is maintained.

Note that in this instance, the revenue from electricity purchases (input tariff) and electricity sales (against output tariffs) is considered to remain in balance. In other words, input cost increases and passed on in proportion to the end-use customers. The focus therefore is on real changes in net income, fixed assets and debtors.

Note that a more prudent approach that could be taken would be to consider smaller phases or more profitable end-use customer markets first. In this manner the sudden increase in fixed assets is limited. Alternatively, it may be more feasible to consider rolling out an AMI or AMR solution for the more profitable sectors (such and commercial and industrial customers) who contribute a greater amount of revenue to the utility.

It is also worth noting that typically, utilities may have easier access to operational expenditure (OPEX) over capital expenditure (CAPEX) so rental-to-own or leased type solutions could be considered as viable financial alternatives.

Technology cost comparison

In comparing the various technologies, various costs need to be considered. In this example, the costs of MMR, AMR and AMI systems will be compared to each other. Fig. 3 illustrates the various components associated with each of these platforms.

In this instance, the ability of a smart metering system to implement load control (via load control relays) is not being considered. Only the costs of meter reading (i.e. revenue collection) will be discussed further.

Data costs of a cellular network

The emergence and maturity of cellular technology has enabled the growth of AMR and AMI platforms and rendered them as viable solutions. Typically this is achieved with an APN (access point name) which allows metering to be allocated a unique IP address. The costs involved with an APN typically include the following:

Table 1: Return on net assets.

<table>
<thead>
<tr>
<th>Year</th>
<th>Increase in fixed assets (asset value)</th>
<th>Reduction in debtors</th>
<th>Increase in net income</th>
<th>Rona %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>12,5%</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>1,6</td>
<td>0,8</td>
<td>12,5%</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>1,2</td>
<td>0,6</td>
<td>12,5%</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0,8</td>
<td>0,4</td>
<td>12,5%</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td></td>
<td>0,2</td>
<td>12,5%</td>
</tr>
</tbody>
</table>

Fig. 3: System components per system platform.

Fig. 4: Comparative APN costs per connection.

Fig. 5: Comparison of platform costs for a three-phase system.
The initial setup costs (SAPN) include the APN creation as well as the installation of leased lines (or similar connectivity) between the GSM network and the master station server. Fig. 4 illustrates these costs against the number of connections (or meters).

In terms of operating costs, the main difference between and AMR and AMI systems is that the last mile communications of an AMR system is based on GSM or GPRS technology. In other words, the master station makes an IP connection to each meter via the GSM network whereas in smart metering or AMI systems, these connections are drastically reduced because GSM connections are only required with each data concentrator. Each data concentrator then communicates with each meter connected to it (anywhere from 20 to 500 devices or meters) using either power-line carrier (PLC) or wireless RF (ZigBee) communications. In AMI systems the cost of the last mile communications (PLC or RF) is usually included in the hardware cost and does not involve licencing or monthly fees.

MMR costs
The costs of an MMR system are represented by:

\[ C_{MMR} = (M_T + M_R \cdot p) \cdot n \]

where:
- \( C_{MMR} \) = Total MMR platform cost
- \( M_T \) = Hardware cost of the meter
- \( M_R \) = Meter reading service cost per meter per month
- \( p \) = Project period (months)
- \( n \) = Number of metering points or end-users

Note that the project period (in months) is used as a base for comparison between the various systems. Typically a period equal to the shortest product lifetime or warranty of any system component would be used.

AMR costs
The costs of an AMR system are represented by:

\[ C_{AMR} = (M_T + M_D + C_{GSM} \cdot p) \cdot n + (S_{APN} + C_{APN} \cdot p) \]

where:
- \( C_{AMR} \) = Total AMR platform cost
- \( M_T \) = Hardware cost of the meter
- \( M_D \) = Hardware cost of the AMR ready meter
- \( C_{GSM} \) = Cost per meter or connection per month for GSM network traffic (including SIM card)
- \( p \) = Project period (months)
- \( R \) = Concentration ratio of meters per data concentrator
- \( n \) = Number of metering points or end-users
- \( S_{APN} \) = Initial setup costs for an APN system
- \( C_{APN} \) = Fixed cost per month for an APN (irrespective of usage)

AMI costs
The costs of an AMI system are represented by:

\[ C_{AMI}(M_T + M_D + C_{GSM} \cdot p) \cdot n + (S_{APN} + C_{APN} \cdot p) \]

where:
- \( C_{AMI} \) = Total AMI platform cost
- \( M_T \) = Hardware cost of the meter
- \( M_D \) = Hardware cost of the AMI ready meter
- \( C_{GSM} \) = Cost per meter or connection per month for GSM network traffic (including SIM card)
- \( p \) = Project period (months)
- \( R \) = Concentration ratio of meters per data concentrator
- \( n \) = Number of metering points or end-users
- \( S_{APN} \) = Initial setup costs for an APN system
- \( C_{APN} \) = Fixed cost per month for an APN (irrespective of usage)

Cost comparison results
Using the formulas for each platform, we can consider two scenarios namely, the deployment of new technology for three-phase commercial and industrial customers and the case of deployment for single-phase residential customers.