Infrastructure asset management and benchmarking to address electricity distribution service delivery challenges

by Linsey Dyer and Chris von Holdt, Africon

Municipal electricity distributors face significant challenges in delivering on their basic license requirements. Although many of these challenges cannot be dealt with at the departmental or municipal level, the adoption of a culture of asset management and service delivery benchmarking with other South African electricity distributors can provide a basis and incentives for service delivery improvements. This paper provides high level learnings from a recent series of technical audits of municipal electricity distributors carried out on behalf of the National Energy Regulator of South Africa (Nersa), including a summary of the key findings (demonstrating that these go beyond financial and technical issues), an overview of the asset management principles used as part of the assessment framework, as well as conclusions and some recommendations from a review of benchmarking approaches. Five strategic pillars for Nersa to drive service delivery improvement are proposed.

This paper represents the authors’ views and not necessarily those of Nersa. Since the final audit report is currently under consideration by Nersa’s Board, the detailed audit results are not presented, although key trends, issues and challenges identified are addressed.

Background

In 2007 Nersa commissioned a study to establish the physical status of electricity distribution networks in twenty municipalities as well as the adequacy of the effectiveness of their operations and asset management activities through technical audits of twenty municipal electricity distributors. Rather than simply assess the networks’ technical condition, Nersa agreed to take a holistic look at the distributors through a business assessment carried out in conjunction with the basic condition assessment. This approach allowed for the development of a more comprehensive understanding of the issues and constraints facing municipal electricity distributors. The assignment represented a third phase of technical audits of municipal electricity distributors. The findings of phases one and two were published in the media, and it is anticipated that the findings of this third phase will be similarly disseminated.

Methodology and key findings of condition assessment

The condition assessment was carried out by means of a walk through, non intrusive, visual inspection of the electrical network infrastructure. Design records, site maintenance logs and inspection records and a variety of other pertinent documentation were also inspected. It was also verified if safety equipment such as operating stocks, safety earths and fire extinguishers were appropriately tested, stored and maintained. The audit team was accompanied on site by the distributors’ representative.

It should be noted that the condition assessments were typically carried out over very short periods (one to two days each), touching on a small yet nevertheless representative proportion of each audited municipality’s network, and should not be considered as comprehensive.

The key findings were that battery systems, large transformers and medium voltage (MV) switchgear were vulnerable. It was also noted that equipment overload was a common practice and that critical equipment was still in use well beyond its design life.

Factors affecting observed equipment condition

Some underlying issues leading to deteriorating equipment condition were identified during the condition assessment:

• Copper theft
• Municipal funding strategies
• The role of the municipal finance department with respect to operations in the electricity department
• Staff morale.

It has been reported in the media that load shedding over the last six months has further affected substations in particular.

Copper theft: Copper theft affects network reliability and the availability of staff to carry out regular scheduled maintenance. Furthermore, it “leaches” capital and operating budget away from needed investment and maintenance.
Municipal funding strategies: Municipal funding strategies currently imposed by national policy appear to be having unintended negative consequences in terms of network refurbishment and replacement. Several department heads cited lengthy periods during which they received no capital budget; one department reported that they had received no capital budget in eight years.

Role of the Finance Department: It was noted that in the majority of the departments audited, the finance department has full control over the financial aspects of the electricity department’s operations, in some cases extending to the procurement process of emergency stores as well as decision-making on stock levels of emergency items. In some cases, it was reported that emergency works could not be done due to the unavailability of emergency items in the stores. It should also be noted that electricity departments reported challenges related to other support services such as procurement/supply chain management and human resources.

Morale: Constraints on funding and other support services also appear to have a direct effect on the morale of senior electricity department staff, who often expressed a high degree of frustration and a sense that the network would probably collapse if they were to retire. In departments which reported serious constraints on human resources, particularly difficulty in recruiting and retaining appropriately skilled technical staff, the morale was often very low. The “Hollywood Syndrome”, in which senior staff have been acting in their positions for several years, was also reported to negatively affect morale. This has led to a growing lack of accountability at the operational and departmental management level, as these acting staff often do not have the authority to carry out essential departmental functions. It has also led to implementation delays related to delays in getting authorisations and approvals.

Methodology and key findings of business assessment

Taken in conjunction with the challenges of coping with natural growth and replacement of ageing equipment, the above issues point to a need for an institutionally-driven solution informed by an understanding of the electricity distribution business as a whole. This provided the rationale for the business assessment, which was performed by means of an interview based on asset management principles with the distributors’ representative. Further information regarding the condition of the equipment, maintenance and breakdown history was obtained during the interview.

Infrastructure asset management principles

Infrastructure asset management was assessed in six key performance areas (KPAs):

- Asset knowledge
- Strategic planning processes
- Infrastructure asset management practices
- Asset management planning
- Information systems
- Organisational tactics

These KPAs typically address aspects such as those shown in Table 1.

<table>
<thead>
<tr>
<th>ASSET KNOWLEDGE</th>
<th>INFRASTRUCTURE MANAGEMENT</th>
<th>INFORMATION SYSTEMS</th>
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<td>Project Identification</td>
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<td>Lifecycle cost data</td>
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<td>Asset age &amp; lives</td>
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<th>STRATEGIC PLANNING</th>
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<td>Failure prediction</td>
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Table 1: Key Performance Areas and the asset management aspects.
Key findings

The key trends arising from the findings and recommendations of the business assessment were that the three fundamental electricity distribution business processes – planning, funding and implementation – are areas of weakness in most of the electricity distributors audited, due to factors such as:

- Attitude
- Lack of an asset management culture
- Challenges with data and reporting
- Funding and financial management strategies
- Political and socioeconomic factors
- Human resources constraints
- Copper theft
- Organisational structure
- Organisational commitment to infrastructure asset management
- Challenges to integrated planning between the key departments

The business assessment also noted that the above issues tend to affect municipalities’ ability to report on compliance with Nersa license conditions and electricity service delivery in general.

Attitude

The field audits found that staff and management attitude within the Municipality and the electricity department was critical to service delivery. They noted examples where with little to no resources, staff were innovative and developed solutions to address specific challenges.

Asset management culture

The main trends identified were:

- Lack of an analysis framework
- Lack of training in techniques
- Lack of knowledge and understanding of GAMAP compliance requirements
- Lack of links with the Municipality’s IDP.

Given that the asset register is the basis of asset management planning, there is a strong case to support the compilation of comprehensive asset registers that contains adequate technical and financial data to support asset management planning and accounting compliance.

Technical support that Nersa can provide to the municipalities includes:

- Standardised asset hierarchy with a catalogue of assets;
- Schedule of minimum data requirements;
- Standardised assessment method (e.g. condition definitions, asset lives);
- Standardised analysis method; and
- Standardised reporting framework;

It should be noted that the Electricity Distribution Industry (EDI) Holdings Valuation Toolkit provides a valuation model for electricity assets, but does not stipulate the technical and financial data requirements for asset management (or for GAMAP/GRAP compliance). A standardised approach would have significant benefits to municipalities:

- It would reduce the cost of learning and development
- It would allow the municipalities to benchmark themselves against one another
- It would allow the rolling up of information to communicate the needs of municipalities to higher levels of government and to inform funding strategies.

Data and reporting

The main trends identified were:

- Finance and electricity departments often don’t use the same data sets for reporting. Electricity departments appeared to feel that they have an obligation to fill out many forms and information requests asking for
“almost” the same data, and several expressed the frustration that government departments do not appear to align their information gathering requirements either in terms of content or reporting period.

- Further to this point, the electricity departments often did not have access to updated financial information. The quality and accuracy of the data provided was questionable. This can have impacts on the development of reliable performance indicators.
- Capital and operating expenditure were not available for any of the municipalities surveyed. In some cases, however, total expenditure was available.
- The municipalities appeared to find the process of reporting compliance with NRS047 and NRS048 onerous. While the municipalities reported that they record and address customer complaints by addressing outages, they typically did not record information on outage frequency or duration.
- The D forms appear to be a significant challenge for municipalities to prepare and submit. Accuracy and completeness appeared to be low. This likely relates to the first and second points above regarding availability of basic data.

**Funding and financial management strategies**

The main trends identified were:

- In several cases, National Treasury policy constrained municipalities and departments to incremental budgeting with a 5% cap rather than zero-based budgeting for maintenance
- Budgets for capex and opex were often not developed separately or may overlap
- Tariffs were often not designed to be cost reflective, since the businesses were not ringfenced – with the result that direct and indirect costs of electricity service delivery could not be assessed.

**Political and socioeconomic factors**

Political and socioeconomic factors such as customers’ ability and willingness to pay are a well known and well-documented challenge to the EDI (Africon, 2005). Non-technical losses affect the labour productivity and financial viability of electricity distributors, although the effect on the business tends to be masked due to historic underinvestment in the network which could make the distributors appear more profitable than they are.

**Human resources**

This appeared to be a critical issue spanning all the Municipalities.

- There are very high vacancy levels, particularly for positions requiring technical and managerial skills
- The cost of acquiring skills is high, and most municipalities cannot compete with other public and private sector employers
- It was cited in several audits by different audit teams that affirmative action is hindering acquisition of appropriate skills at affordable levels. While this may be considered a political or inflammatory observation, it was mentioned often enough as a factor significantly affecting skills acquisition and retention (and in some cases staff and equipment safety) in the different electricity distributors audited to be considered an issue to be dealt with differently, and is therefore reported here.

**Copper theft**

All distributors audited were significantly affected by the national challenge of copper theft, which affects earth wires and cables. This is an external factor over which the distributors tend to have very little control, yet which has strong influence over outages, O&M costs and labour productivity.

Media reports during the report preparation period indicated that some municipalities were taking police action against this type of crime, however, it was acknowledged that such campaigns take significant resources. It is critical that national government resolve the lack of regulation of the scrap metal market, which is one of the principle reasons copper theft is endemic in South Africa. Moves to categorise copper as a precious metal, which would make it far more difficult for scrap metal dealers to trade in copper, would significantly assist electricity distributors. Some distributors are considering the use of different conductor, not attractive to the scrap metal market.

**Organisational structure**

Because these distributors are typically structured as departments rather than business units as defined in the Municipal Systems Act, the organisational structures do not easily support business-like operation. It appeared that in general the electricity department head could not be in full control of his business, and did not always have up to date, accurate financial information unless he set up parallel systems.
Organisational commitment to infrastructure asset management

It appears that municipalities, while very committed to immediate service delivery needs, do not have the same level of commitment to meeting long term infrastructure management goals. There appeared to be a focus with respect to immediate community needs such as connection backlogs, and a lack of focus on business planning and long term planning. Specifically with respect to electricity, this translates into a disconnect between the electricity departments and the municipalities in terms of budgeting and planning, as well as the reinvestment of funds generated by the electricity business.

Challenges to integrated planning

There also appears to be a fundamental challenge at municipal leadership level (and possibly escalating to provincial and national level) to integrating development planning. Despite the rigorous and by now familiar IDP framework, electricity departments often expressed a high level of frustration with their counterpart department for housing, particularly with respect to obtaining funding to address backlogs. Some electricity departments reported that housing departments do not communicate plans to, for instance, proclaim areas relating to informal housing, or plans for large scale housing development, which would have an influence on both electrification planning and bulk supply planning.

Future shock

The picture painted above is already quite bleak, but becomes even more sobering when put into a context of proper infrastructure asset management. According to UBS research presented recently by EDI Holdings (EDI Holdings, May 2008):

“In addition to the lack of investment in generating capacity, the South African electricity distribution network is (according to industry experts) also in a state of critical under-investment. Eskom is responsible for 95% of generation and 100% of transmission. Distribution, however, is owned about 50-50 between Eskom itself and the “munics” (municipality-owned distribution companies). As a rule of thumb, distribution companies should be investing at a rate of about 10% of asset value per year. However, for a number of reasons beyond the scope of this report, investment rates in many (especially non-Eskom) distribution companies are as low as 1-2% per year. Thus, while much of the focus has been on generating capacity, a major threat to efficient energy supply is distribution.”

Based on this thinking, EDI Holdings estimates the maintenance and refurbishment requirement over the next six years as shown in Fig. 1.

![Fig. 1: Maintenance and refurbishment requirement in South Africa’s electricity distribution networks (EDI Holdings, May 2008).](image-url)

Unfortunately, this isn’t the whole story. Quite separately from planning for maintenance and refurbishment expenditure, planning must also take into account natural growth and asset retirement. This means network capacity planning account expansion due to load growth (i.e. new connections) as well as equipment replacement due to ageing.
Most electrical equipment has an expected life time of 25 to 50 years, which means that this equipment has the risk of failure after 25 to 50 years, after which it is time to replace it. This implies that 2 to 4% of the equipment must be replaced annually, based on the thinking that for a design life of 25 years, all original equipment should be replaced at an average rate of 4% per year (100% divided by 25 years), and similarly for a design life of 50 years, a 2% per annum replacement rate is needed. As shown in Fig. 2, which illustrates the combined effects of load growth and equipment ageing on capacity requirements, under a relatively conservative scenario of 5% load growth and 2% replacement, the network capacity would still need to be doubled within ten years. An accelerated growth (7.5%) and replacement (4%) scenario would imply a need for network replacement within six years.

Fig. 2: Capacity multiplier taking into account growth and replacement of ageing equipment.

Currently the time frame for planning, design procurement and implementation of a typical medium size substation is of the order of 27 months, including obtaining approval for finance, procuring long lead time items and implementing the project.

Many manufacturers are now reporting heavy production backlogs due to lack of capacity (related to lack of consolidated communication on backlogs, which hampers their own ability to motivate production capacity increases), and often cite lead times of 18 months for equipment such as transformers and switchgear. It should be noted that in addition to municipalities, Eskom Generation, Eskom Transmission, Eskom Distribution, private industry, the railway industry and foreign electricity suppliers also need to purchase equipment from the same supplier base.

Even if it is argued that the above figures are 100% inaccurate, the implication is still that South Africa will have to double its electricity distribution capacity within 12 to 20 years.

**Benchmarking**

The need to address the current and pending challenges in electricity distribution is clear. Nersa has adopted an approach of incentive based regulation, which is considered by experts in network based utility regulation (notably Coelli et al, 2003) to be the most effective approach for driving service delivery, typically in conjunction with a clear benchmarking programme based on rigorous data collection. The technical audit also required recommendations on a benchmarking strategy, including benchmarking against international utilities.

Two families of benchmarking methodologies which can be used under incentive regulation were reviewed, frontier and average benchmarking. Both are ultimately aimed at improving efficiency within a specific organization by providing it with comparative performance information. Coelli et al (2003) provide a comprehensive and approachable guide to the economic theory behind efficiency improvement in utilities, and how regulators can practically incorporate this thinking. Coelli and Lawrence (2006), a compendium of thinking on performance measurement and regulation of network utilities, provides excellent further reading.
Frontier benchmarking

Frontier, or “target best practice”, benchmarking, is done by comparing the relative performance of firms to the efficient frontier, or outer limit – basically, by definition, whoever is doing it best is on the frontier. Linked to incentive regulation, this benchmarking approach is used to encourage the regulated firms to achieve the identified frontier performance.

These methods require significant amounts of data in order for meaningful results to be derived. They require relatively high skills levels in handling large data sets, statistical analysis and reporting.

Frontier benchmarking also requires high confidence levels in the comparison data, from the following perspectives:

- The selected frontier must be credible and verifiable on each of the variables measured. In practical terms, this means that best practice cannot be arbitrarily set, nor can it be decided from a small sample in which it is unclear that the full range of experience has been taken into account.
- Credibility of the data also implies that the basic data quality should be good.
- There should be a high level of confidence that the data from one utility can be compared with that from another, and that the best practice selected is therefore a “fair” target.

Jamasb and Pollitt (2001) note that the most challenging issue for international benchmarking is the comparability and quality of data. They further advise that a fundamental issue with using frontier methods is that it may not be clear that the frontier is a valid comparator. Also, they caution that the likely rate of future movement of the frontier can be problematic: “Measures of past productivity growth usually include both frontier shift effects and movement towards the frontier.”

Average benchmarking

Benchmarking in incentive regulation can be in relation to some statistical mean or average measure of performance of the selected group of utilities, without making reference to external utilities. Selected indicators can be compared using a variety of techniques, from complex regression methodologies to simple averaging.

Jamasb and Pollitt (2001) advise that average benchmarking can be used to “mimic competition among firms with relatively similar costs or when there is lack of sufficient data and comparators for the application of frontier methods”. They also cite a variety of approaches using average benchmarking. In the United States, for example, they report that Performance Based Regulation may make use of a sliding scale method, where there is a dead band around a target rate of return. They also cite, as do other references (Coelli, Estache, Perelman and Trujillo, 2003, and Coelli and Lawrence, 2006), the use of Total Factor Productivity (TFP) as the benchmark. The Tornqvist index is often cited as a measure of historical productivity growth.

In the absence of massive data sets, one advantage of this approach is that simple averages can be used. Agencies charged with improving service delivery among a set of utilities can simply use the average performance as a basis for establishing the extremes of performance. They can also simply use the data available to them locally, for example, in a Utility Scorecard.

![Fig. 3: Example of a Utility Scorecard (Kingdom and Jagannathan, 2001).](image-url)
In a World Bank paper which is often referenced in other papers, Kingdom and Jagannathan (2001) recommend incentive regulation based on average benchmarking and publication of progress on selected performance indicators on a simple, easy to understand scorecard. They present the powerful example in Fig. 3, which compares English and Welsh water utilities’ performance in a simple format readily understood by the public. The publication of these scorecards provides a focal point for the utilities’ customers to demand improved service delivery, and also tends to foster more competitive behaviour in what is inherently a monopolistic market.

**How to develop a utility scorecard**

An example of average benchmarking used in a public scorecard in Africa is the recently announced African Governance Index developed on behalf of the Mo Ibrahim Foundation (www.moibrahimfoundation.org). Although not an infrastructure benchmarking tool, this index nevertheless deals with very politically sensitive factors using objective measures, and then uses extensive publicity to communicate performance measured. South Africa scored 5 out of 48 on the composite of the five point scale used.

Using clear, measurable indicators, the index compares 48 countries with respect to 58 individual indicators grouped into five categories of what they term “essential political goods”, clearly capturing status on objective outcomes. The website provides extensive information on methodology. Rotberg and Gisselquist (2007), who directed the development of the Index, provide excellent guidance on the considerations of developing a politically sensitive index. In particular, the descriptions of the process used to arrive at the weighting factors and considerations of future adjustments are illuminating. It is clear that much thought, discussion and debate went into the selection of the indicators, the sources of data and potential updates to the index.

The assessment of potential benchmarking strategies demonstrated that benchmarking South Africa’s distributors between each other on a limited set of key performance indicators is likely to drive performance and improvements in service delivery better than benchmarking them against international distributors.

**What to measure?**

The study recommends a basket of indicator families from which to derive a single numeric score like the African Governance Index, based on internal and external performance drivers.

In order to complete the business performance improvement picture, it is necessary to identify indicators which are internal (i.e. within the distributor) performance drivers rather than external (i.e. from Nersa). External factors include key license conditions and compliance requirements, on the basis that these drive performance to a significant extent. It is advantageous to identify internal measures used in selected distributors, on the basis that these are used to drive self-improvement for both sustainability and compliance reasons.

While it is extremely difficult to obtain information on internal performance improvement drivers from individual utilities, the World Bank has developed a comprehensive database for electricity distribution utilities in Latin America and the Caribbean, incorporating data from 1995 to 2005 over a range of indicators.

Under this study (http://info.worldbank.org/etools/lacelectricity/), data from some 249 private and state-owned utilities using 26 variables aimed at measuring technical, operating and cost efficiency, quality of service, and a number of other indicators at the utility level is grouped into six categories of variables:

- Output
- Input
- Operating performance
- Quality and customer service
- Price
- Labour productivity

The study acknowledges that data availability and sources vary from country to country, often depending on ownership and means of regulation. Other factors mentioned included:

- Variance in country and utility size
- Time and process of privatisation
- Geography
- Subsidies

Based on the study, the basket of indicators shown in Table 2 are recommended to be established as the basis for an average benchmarking approach within South Africa’s electricity distribution industry.
Table 2: Recommended electricity distribution performance indicators.

Customer based network reliability indices such as the System Average Interruption Frequency Index (SAIFI), Customer Average Interruption Duration Index (CAIDI) and System Average Interruption Duration Index (SAIDI) are very well documented (Chatterton and Chatterton et al, 2005) and can be assumed to be a customer service indicator.

What about getting the public involved in service delivery assessment?

This may sound extremely difficult for a complex service such as electricity distribution, but it is already being done to great effect worldwide in water and other infrastructure service delivery through so-called “Citizen Report Cards” (Wagle et al, 2004).

The use of Citizen Report Cards as public accountability mechanisms to drive performance and quality of government services is growing. Quite simply, they allow citizens to monitor state performance, and:

- Provide quantitative information from the consumers’ perspective
- Can assist in prioritizing reform efforts and resource allocation
- Aggregate and communicate the reality of the poor to decision makers and the public at large
- Foster discussion and debate
- Treat users of public services as clients and customers whose voices matter in the design, delivery and assessment of government services.

Citizen Report Cards can be institutionalized in different ways. Table 3 presents a sample range of institutional options in use globally.

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<tr>
<th>Administering Agency</th>
<th>Advantage</th>
<th>Examples</th>
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<td>Civil society organization</td>
<td>Builds public pressure for reform</td>
<td>Public Affairs Centre, Bangalore</td>
</tr>
<tr>
<td>Government service provider agency</td>
<td>Ownership of the process by the agency</td>
<td>United Kingdom, Canada</td>
</tr>
<tr>
<td>Government oversight agency</td>
<td>Most comprehensive in process and product</td>
<td>United States</td>
</tr>
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Table 3: Institutional models for Citizen Report Card implementation (Bureš, 2002).

Bureš (2002) presents examples of public sector report card experiences in Bangalore, India, the Ukraine and the Philippines. Some observations from the examples:

- Public services in Bangalore had improved in the five years since the first report card
- Nearly two-thirds of the poor reported they would be willing to pay more for services if quality and reliability improved
- Quick wins and local champions are important – commitment and engagement of city mayors and local government officials can improve implementation
- Strong monitoring and evaluation are important
• One-time exercises tend not to work well. Incentives for reform and improvement are more likely to increase if the service providers know that they will be assessed again, so institutionalisation of the process is important.

Conclusions and recommendations

The business assessment demonstrated that basic planning, funding and implementation for electricity service delivery are hampered by human resources capacity challenges at all levels of government (not just municipal) and institutional challenges within the municipalities as well as within the enabling structures of government. These challenges affect the electricity distribution business in addition to the more anticipated technical and financial challenges, and in general cannot be dealt with simply at the electricity department or even municipal management level. Unless plans are made to deal with these challenges first and on an ongoing basis, simply addressing technical and financial issues is likely to aggravate rather than improve the situation.

There is a need to radically alter the focus of electricity distribution service delivery monitoring. Five strategic pillars are identified for improving electricity service delivery:

1. **Develop an industry wide skills plan**: assist municipalities to address human resources constraints and challenges by commissioning a skills analysis, championing apprenticeship programmes and engaging with international partners.
2. **Make reporting easier**: support electricity distributors in data collection and reporting, by simplifying and rationalizing the reporting streams and systems.
3. **Make planning easier**: provide templates which will facilitate rolling up of information to communicate the needs of municipalities to higher levels of government and to inform funding strategies. These could include templates for business/master planning and asset register templates to municipalities in order to reduce the level of effort to maintain and update these effectively and accurately.
4. **Stop copper theft**: engage with other government departments to address copper theft. This problem requires a national strategy.
5. **Go public**: develop a single numerical performance index for internal benchmarking purposes within South Africa’s EDI, using a set of critical indicators representing external and internal performance drivers and based on international best practice in benchmarking. Consider going even further and implementing Citizen Report Cards.

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