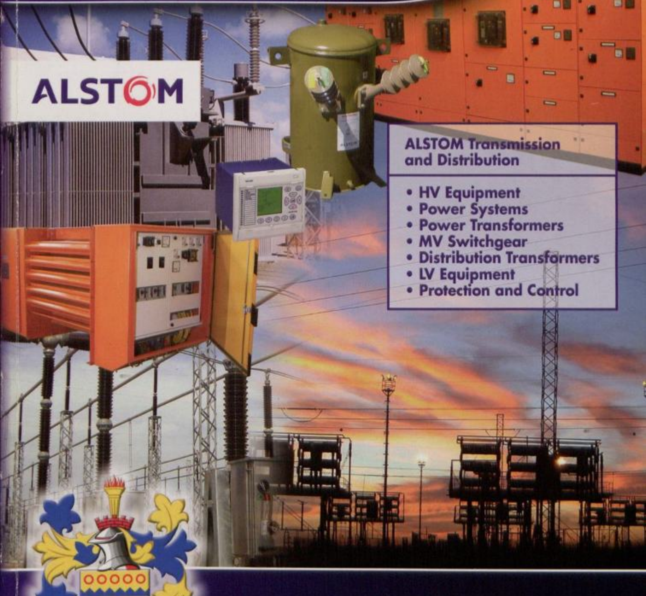
energize
2004
Special AMEU Proceedings Edition



SPECIAL ISSUE

AMEU 20th Technical Meeting

Richards Bay • uMhlatuze • 11 - 12 October 2004

BEE group ALSTOM SA committed to local manufacture

Information from ALSTOM South Africa

Black economic empowerment (BEE) electrical engineering group ALSTOM SA (Pty) Ltd is a leading and longstanding player in energy and transport infrastructure in southern Africa, having been in operation for more than a hundred years.

ALSTOM SA has long been and remains committed to local manufacture. In being so it not only actively demonstrates its long-term commitment to and involvement in the country's development, but also provides numerous employment opportunities directly and indirectly that would not be available were it to pursue a policy of importing products for sale into the domestic market.

Besides strongly penetrating the South African market for infrastructural electrical equipment, systems and services through a combination of introducing advanced technologies, applying imaginative marketing programmes and expanding its operations through the acquisition of complementary businesses, the past few years has also witnessed a burgeoning of ALSTOM SA's business beyond South Africa's borders, resulting in the group's external business now accounting for over 20% of its turnover.

Among the numerous contracts ALSTOM SA has won or completed during the past twelve months or so, or are currently in progress, are:

- Supply of a range of equipment for Eskom's new 132/11 kV Leaches Bay substation, which will supply power to East London's industrial development zone.
- Now close to completion, the turnkey bulk electricity supply infrastructure contract for Coega, worth more than R180-million, which will support the electrical reticulation to service the Coega industrial development zone and deep-sea port.
- Eskom's two-year contracts, worth a total of more than R52-million, for 66 to 400 kV current transformers and 132 kV voltage transformers.
- A turnkey contract for the retrofitting of a pulse jet fabric filter plant in place of the existing electrostatic precipitators of Arnot power station's units 1, 2 & 3.
- A contract in excess of R25-million for Spoornet to upgrade the signalling systems on the railway line linking the Northern Cape town of Postmasburg to the main Kimberley-Cape Town line.
- A turnkey contract for the Department of Water Affairs & Forestry, involving the establishment of a new pump station at Morgenstond Dam near Ermelo, Mpumalanga.
- A three-year contract for Saniam Properties to supply lamp source replacements on a continuous basis for all its properties around the country, comprising mainly of office blocks and shopping malls.
- A R16-million contract for a main distribution board and 25 x 525 V motor control centres controlling some 900 motors for a local platinum mine.

The sale earlier this year of ALSTOM Europe's Transmission and Distribution (T&D) activities to France-based, international energy giant AREVA, leaves ALSTOM SA's T&D operation largely unchanged, with the name ALSTOM T&D being retained in South Africa, selling products and services branded ALSTOM if locally produced and AREVA if imported.

ALSTOM T&D is the exclusive representative of AREVA in Southern Africa.

ALSTOM SA's BEE equity currently stands at 38%. The group's BEE shareholders are Tiso Private Equity, Kagiso Ventures Private Equity, Kgorong Investment Holdings, Sibilant Investments and management.

ALSTOM SA employs 4 500 people and has an annual turnover in excess of R2-billion. It has 25 operating units, including two empowerment subsidiaries, 20 production facilities and 21 distribution centres throughout Southern Africa.

ALSTOM SA has exclusive distribution, technology and representation rights for ALSTOM and AREVA in Southern Africa and maintains management and commercial links to the ALSTOM and AREVA business units in Europe.

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AMEU Proceedings

20th Technical Meeting and Special Convention

"Electricity distribution - getting it right"

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Valedictory address

Peter Fowles, president of the AMEU

It is not normal for the president of the AMEU to make a valedictory address at a Technical Meeting but as this is also a Special Convention, I trust you will condone this variation from standard procedure and allow me a few minutes of your time as I, unfortunately will not be your president at the next formal convention to be held in Polokwane, sometime during September 2005.

Many of you will have read in the June 2004 edition of AMEU News, the open letter I wrote to try and explain my reasons for leaving my employment with the Msunduzi Municipality. I will not go over that ground again except to say that it was an incredibly difficult decision to make as I would, as a consequence of that decision, not be able to honour the trust placed in me by the membership and the executive council for the full period of office for an AMEU president.

The numerous expressions of understanding and messages of support of my actions have been sincerely appreciated. My grateful thanks are also extended to the members of the executive council for agreeing to support the continuation of my duties from July to December 2004. This was after the Msunduzi municipality petulantly withdrew their support, even though their mayor had publicly expressed their support for my two year term of office at the Pietermaritzburg Convention.

Since the commencement of NELF in 1992, I have personally lived in the hope that we could move the electricity distribution industry in South Africa into a new dispensation, better equipped to serve our customers than the current fragmented structure. I was delighted that Phindile Nzimande, CEO of the recently formed EDI Holdings Company was present at the convention in Pietermaritzburg to present her vision of the path that would be followed to achieve government's objective of creating six financially viable, autonomous Regional Electricity Distributors (REDs).

I, and many others, have worked passionately to bring this vision into focus and towards the beginning of this year, your executive council finalised an AMEU strategy for circulation to its members. If by any chance you have not received a copy, it is available on the AMEU website.

This document unequivocally supports the achievements of the government's vision and advises our members to prepare their organisations to merge into the eventual structure by, amongst other activities, undertaking a review of their electricity service

delivery mechanism as specified on section 78 of the Municipal Systems Act and ring fencing the electricity distribution function.

I have voiced my opinion on what needs to be done in local authorities at a number of stakeholder meetings organised by EDI Holdings to plan the way forward, much to the consternation and annoyance of some of our financial colleagues in a sister municipal institute. I make no apology for this passionate pursuit of the restructuring objectives as, in my travels over the last year or more, I have seen more and more of our engineer members struggling in a chaotic situation to provide a reasonable level of service while plagued by a shortage of human resources and adequate finance coupled with increasingly bureaucratic demands.

One of our financial colleagues proudly claimed during a recent conference that the electricity service is a municipality's 'cash cow', which they were not prepared to give up. My response was that most municipalities had not only milked the cow dry, they were now in the process of raping the poor thing.

An article in the July 2004 edition of IEE Review describes the results of a survey conducted in the United Kingdom which concluded that 'energy managers in the engineering sector are overworked, have no energy for family commitments, and work in a negative environment'.

Could this also describe the situation for our municipal electricity distributor managers? Would they identify with the conclusion reached in the UK that 'employees are not afraid to work at this level providing their ideas are heard and they can be made to feel valued, empowered and are allowed to work more flexibly'?

The article concludes that "it is only when people feel a close, meaningful involvement with their organisation that they bring energy, enthusiasm and passion to their work."

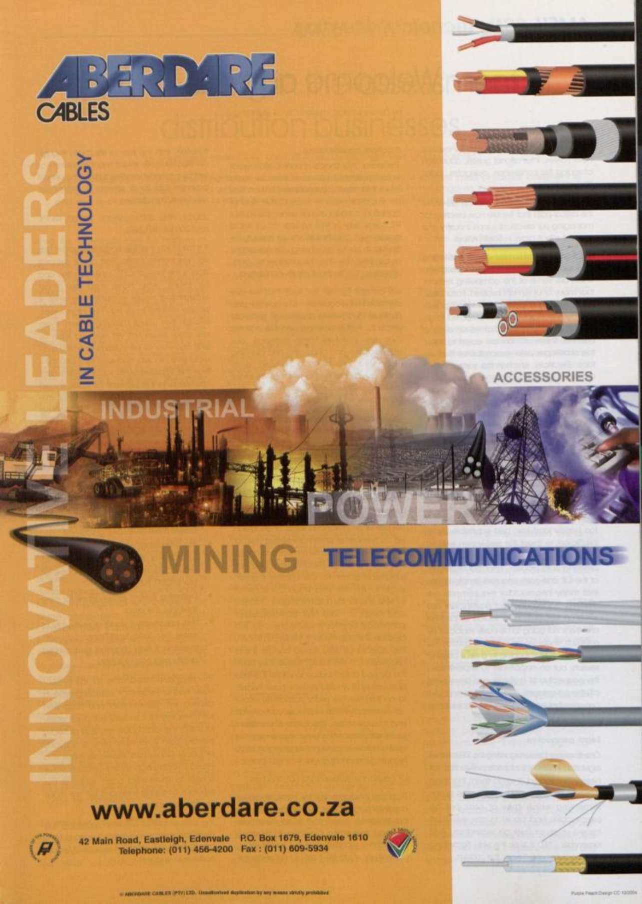
Unfortunately, I will not be involved much longer in the process of trying to establish the regional distributors. I therefore appeal to all of you to do whatever you can to assist EDI Holdings to facilitate the restructuring. You have my very best wishes for this difficult task and I trust that God will bless your efforts.

To conclude, I would like to thank a few people:

- Howard Whitehead for involving me in the activities of the AMEU and convincing me that I could make a contribution
- John Ehrich for his wise counsel as immediate past-president and for bringing me back to reality when I go of at the deep end
- Danie Potgieter for his unswerving support as president-elect and for agreeing to take over as president nine months before his normal term of office would commence
- Jean Venter and his team, Gillian Adri, Germinah and Anna for their wonderful support
- Trevor van Niekerk and the AMEU affiliates who make possible and enrich many of our activities
- At van der Merwe, Harden Beck and Deon Louw who have given so much to this organisation and who have now moved onto other roles
- The numerous staff of AMEU members, many of whom can not be here today, who willingly give of their time and expertise for the benefit of our association and our industry
- My wife, Marilyn, and daughter, Ashleigh, for their sacrifices over the past few years that allowed me to carry out AMEU duties.

It has been a privilege and a great pleasure for me to be part of an organisation with such a proud history and that continues to contribute to a better future for our customers and our people.

Thank you. Δ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Welcome address

by Denny Moffatt, mayor, City of uMhlathuze

Mr. Master of Ceremonies, AMEU President Peter Fowles, international guests, councillors attending this conference, delegates, ladies and gentleman...

South Africa's engineers are the drivers of the critical path that we are now creating for managing our electrical supply industry and the vital role it plays in South Africa.

Local government is a dynamic, challenging and extremely complicated operation, which are some of the compelling reasons that many of us remain involved. Fortunately, I also have the privilege of working with competent officials who are prepared to go the extra mile to ensure that we run a good business. These officials are eager to meet the challenges and responsibilities that we face. Electricity, which in this years budget makes up 48% of our income, plays a major role in our economy and so if any changes look as though they may threaten our performance, then you can be sure that we will take a good look at the situation and carefuly consider the implications.

The often legitimate complaints that local government has not delivered fast enough, especially to the previously disadvantaged community, needs to be dealt with. We simply do not have the financial resources to quick fix the enormous backlogs. Our tax base is too narrow and low, and equitable share insufficient to meet the well-known wish list created by the integrated development planning (IDP) process. Financial alignment of the IDP and cash resources simply means that many infrastructural requirements are delayed. Traditionally local government has relied on electricity as a source of income and this is not going to be easily replaced by a system where we do not have control. This is not, by the way, leading to a REDs bashing session, but an opportunity to explore from the perspective of a vibrant and developing city the advantages, disadvantages and also concerns that we are facing. I also have some local issues to share with you.

Legal perspective

One important issue regarding the REDs is that legislation in respect of participation has not been promulgated. It would seem that there is choice as to whether to participate or not, something which may or may not be practicable, and could in any event be forced upon us through legislation. And remember - RED 1 is on the way. Something like "the terminator" from the movies.

Practical considerations

The reason that choice of participation needs to be considered is because there are many issues that need to be addressed which play an important role in running this kind of operation. It should also be remembered that Richards Bay is not typical of all local government, and that today we need to be flexible in so far as running our operations according to the requirements and, ultimately, the financial results concerned.

We cannot ignore the fact that we are authorised in the constitution to supply, transmit, distribute and (where applicable) generate electricity. Furthermore the constitution states that we structure and manage our administration and budgeting and planning processes to give priority to the basic needs of the community, and to promote the social and economic development of the community.

The Systems Act also expects us to have tariffs which include lifeline tariffs for basic services, as well as making provision for the promotion of local economic development (LED) through special tariffs for categories of commercial and industrial users. To do this we need to be able to negotiate a variety of issues and incentives with major investors. These include the costs of land and services. We are at an advanced stage of discussion with a number of potential investors. Two of these are a ferro chrome smelter and a pulp mill. Both are foreign direct investors and their requirements are: for the chrome smelter: stage I - 67 MW, and stage 2 - a further 67 MW; and for the pulp mill stage 1 - 130 MW and stage 2 - 240 MW. Both represent enormous capital investment and job creation. The pulp mill is R2,5-billion on its own. The question is who would handle these negotiations in the future? Would they have the fire and determination to attract this type of investment? Would they even have the skills to do this? We are pretty passionate about our development, as I am sure your officials and councillors are. Resolution of important issues with Eskom has been slow to say the least and it does not seem that a clear strategy regarding important investment is in place.

Of course the problems do not stop here.

Electricity broadens our tax base, improves our ability to raise capital trough strengthening our balance sheet and is an extremely powerful tool when it comes to revenue collection. I wonder what our credit rating (currently A) would be if we did not retain this function. With the sale of electricity through an electronically linked financial system as well as a prepaid vending system, the annual payment rate for all services in uMhlathuze has been the following:

2000/1: 98%; 2001/2: 99,3%; 2002/3: 95.7% and 2003/4: 101,56%

It is fair to say that this enviable situation has set new bench marks. Part of this success story is the work of CEE Danie van Wyk and his team, who have had the most outstanding results in controlling what is politely referred to as non technical losses, through their check metering system. There are other issues not yet resolved such as staff and who will bill customers, which is an expensive process to duplicate. I also think that the improvements local government has made in the provision of water should be looked at when considering the distribution of electricity. If you want to be given a hard time, just visit Eskom supply areas and raise the issue of electricity!

The City is involved in discussions with a company who propose the construction of a 500 MW power plant that could be built in two stages which would have major, advantages to us. These woud include:

- Improvements in power quality: Eskom barely meet SANS 048 guidelines.
- The technology of combined cycle gas turbines is the next best thing to renewable energy and supportive of the KYOTO PROTOCOL.
- Deferring Eskom expenditure for new lines into the area.
- Very importantly it would allow the city to enter into long term contracts with investors if they required guaranteed quality and cost of supply.

The engineers responsible for this project have had a somewhat frustrating time in dealing with Government and Sasol and we have, serious concerns about our ability to satisfy the reasonable requests of heavy industry, both in terms of price and quality of supply. Consumers, especially those who intend investing high capital amounts, have a right to know what costs will be in the medium and long term and will not make uninformed decisions.

The critical role of decision makers in the electrical supply and distribution industry is an important part of South Africa's economic success. Δ

Benchmarking in the assessment of distribution businesses

by David Bailey, Floren Castro and Cliff Jones, Sinclair Knight Merz, UK and Australia

This paper attempts to bring together a number of issues relevant to the determination of efficient levels of capital investment in electrical distribution businesses. It draws upon modelling techniques employed in the United Kingdom, Australia and Argentina, and also upon information available to distribution network operators and to energy industry regulators in those locations.

Whilst the techniques may be applied in other jurisdictions, one of the key determinants to the usefulness of such techniques is access to the necessary network information. The paper fistly replays the benchmarking applied during the 1999 review of the GB distribution businesses and gives an indication of the higher level approach that could be adopted by an energy regulator when presented with comparable information from a number of differing distribution businesses. The paper then goes on to give an indication of the investment decisions that may be taken internal to a distribution business, based upon the available network information.

Background

As national governments strive to reduce demands on their expenditure, there is a worldwide trend to move electricity businesses, and other utilities, from state to private ownership. At the same time there is a drive to reduce costs to customers, to enhance quality of service, as well as to seek to fund investment in this essential service area. Transmission and distribution businesses are generally considered to be natural monopolies, as it is not economic for several companies to compete in the same geographic area. Under such conditions there is a possibility of abuse of monopoly power and, without competition, there may be little incentive for companies to reduce costs or improve efficiency. As a consequence it is necessary for such companies to be subject to some control of the charges made to customers. In the United Kingdom and in a number of other countries, 'price cap' regulation is applied allowing incentives for the companies to retain efficiency savings. The 'Price Controls' generally take the form of an assessment of required income with a continuing requirement for efficiency gains that act as a proxy for competition.

GB regulatory review process

In GB, regulatory reviews of distribution price controls are carried out at intervals of 5 years. The third distribution price control conducted by the GB energy regulator, Ofgem, covered changes to the charges for use-of-system and (to a limited extent) connections. The distribution price control was based upon an analysis of the historic and forecast business operating and capital expenditure requirements and assessed efficiency gains.

The distribution charges are permitted to vary each year according to the formula RPI - X, where RPI is the retail prices index (inflation index) and X is an efficiency factor. To date, this form of price control has led to significant price reductions as well as quality improvements for customers. It is this type of control which was subject to consultation in December 2003 by the National Electricity Regulator in South Africa and is the proposed basis for Incentive Based Regulation of both Transmission and Distribution.

Under the GB distribution price control review, Ofgem reviewed the forecast expenditures of the 14 distribution companies in Great Britain, covering the years 2000/01 to 2004/05 [1]. In this paper we describe the techniques that were used in the review of the capital expenditure forecasts submitted by each of the companies. Similar periodic price control reviews are proposed for South Africa, with a proposed 3 year control period initially, to minimise the risk to all stakeholders, prior to settling on a longer, 5 year control period which allows greater scope for efficiency gains by operators with resultant benefits for all.

GB company analysis

Each company was required to submit its capital investment plans in response to an extensive questionnaire. The questionnaire responses indicated forecast investment programmes totalling more than US $10-billion over the 5-year period. As there are 14 distribution companies in Great Britain, there was a good opportunity for benchmarking costs and performance, even for networks as diverse as the high density largely underground cable network of London Electricity and the rural, weather affected, and largely overhead network of Scottish Hydro-Electric.

On distribution networks, capital expenditure is generally classified as follows:

- *Load-related expenditure*, which provides new connections and reinforcements to meet load growth
- *Non-load-related expenditure*, which includes asset replacement, environmental and safety requirements, and system control
- *Quality of supply expenditure*, which results in improvement of reliability, power quality and customer service.

In practice an element of asset replacement may be incorporated in network reinforcements driven by demand growth, and conversely replacement of older assets may well deliver improvements in quality of supply and also additional network capacity if assets are not replaced on like-for-like basis. However, when taken overall the classification of expenditure into the three categories identified above is generally relatively consistent between companies, partly due to the discipline and common practices imposed on such companies prior to privatisation.

In the case of South Africa where distribution network operators may be historically quite different, a certain degree of regulatory guidance may be necessary to ensure that such information is provided in a consistent way.

An initial review was made of the underlying drivers such as increasing customer numbers, increased demand, load movements from one area to another and also the need to replace ageing and poor performing equipment. This indicated significant differences between normalised expenditure forecasts of the various companies.

These variances were attributed in part to specific company efficiency savings and also to factors outside the companies' control, especially differing levels of growth in customer numbers and demand. The deployment of new IT systems to record and analyse better the condition of network assets and hence replacement expenditure was identified as an important factor in the reduced expenditure forecasts of some of the companies.

Benchmarking of capital expenditure

Load-related expenditure influence of load movement

The growth in power demand in Great Britain is low with average annual long-term growth in peak power and energy demands being only 0,6% and 1,2% respectively. A model of marginal cost of distribution network development per additional kW of demand was therefore not considered to be appropriate to review loadrelated expenditure in this instance. Furthermore from the outset, the sheer size and scale of the networks concerned precluded detailed modelling. Initial modelling of cumulative development cost per additional GWh of distributed energy showed that load movement (churn) rather than load growth was a relevant driver. The trend line on Fig. 1 shows clearly that there is an appreciable element of expenditure that is independent of load growth.

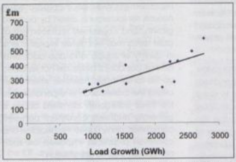

Fig 1: Cumulative load related expenditure v load growth (6 years).

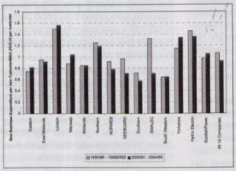

Fig. 2: Normalised load-related expenditure by price control period

New customers as investment driver

After further analysis of historic and forecast expenditure, the relationship between historic expenditure and numbers of new customers was found to be a more stable indicator than distributed energy. This relationship was shown to provide the closest correlation of the models analysed and was applied to set the allowed load related expenditure. Due to the differing natures of the company electrical networks, the expenditure was normalised by comparing the ratios of:

- overall expenditure per new customer with modern equivalent asset (MEA) value per customer and
- new business expenditure per new customer with the MEA value of the medium and low voltage assets per customer.

In so doing it was possible to differentiate between new business (connection) expenditure and the (more deep-seated) reinforcement expenditure. The MEA values were obtained by multiplying the quantities of relevant assets, as declared by the companies, with the corresponding company specific unit costs. The use of MEA/customer is considered to be an appropriate way of characterising the specific nature of the network to which the customer is connected, whether it be a high density urban area or low density rural, providing of course that new customer connections are themselves consistent with the existing customer distribution. Fig. 2 shows expenditure per customer as a proportion of the per customer MEA value for the three price control periods from 1990/91 to 2004/05. An average value of between 0,8 and unity is indicated for all 14 companies, reflecting companies' overall efficiencies and expectations to drive costs down. Without such savings it would otherwise be expected that on a long-term basis this value would be unity.

Viewing expenditure on a longer-term basis also allows for the uneven nature of more deep seated reinforcement expenditure with time. The use of MEA values also implicitly takes into account the historic level of under-utilised assets and hence "churned load" in a company's system. Fig. 3 shows the normalised new business expenditure by price control period and indicates a similar level of correlation to that in Fig. 3. In practice a median rather than an average MEA value per customer was used, so that extremes would not affect the adopted benchmarking position.

A view was then taken on the companies' projections of numbers of new customers, comparing these with historic trends of both customer numbers and energy consumption. The revised forecasts of new customers and the MEA value per customer were then applied to derive a projected expenditure. It should be noted that this exercise highlighted some significant, but illusionary changes in customer numbers which had arisen due to Ofgem initiatives with respect to improving the accuracy of customer records and connectivity.

As a result of the load-related benchmarking process, Ofgem projected a total load-related expenditure of US $3,8-billion, significantly lower than the aggregate of the companies' forecast of US $4,3-billion (i.e. the allowed expenditure was about 88% of that forecast by the companies).

Non-load related expenditure asset replacement modelling

Asset replacement is the principal component of nonload related expenditure, other components including expenditure in respect of safety, environment, diversions and network management.

The basic process of long-term modelling of asset replacement funding requirements is centred upon the cross multiplication for each asset category of the asset quantity of a given age with the assumed replacement rate for that age of asset. The output represents the volume of that asset to be replaced. This asset replacement volume is then multiplied by the appropriate unit replacement cost to give the estimated replacement expenditure for that asset category [2]. The dominant asset categories are transformers, switchgear (including substation civil works), overhead lines, underground cables and service connections to customers, including meters.

Benchmarking of expenditure

The expenditure forecast of each distribution company was reviewed using the following data provided by each company:

- asset age profile data for each asset category (about 40 individual asset categories were analysed)
- asset replacement profiles (percentage of a given asset population replaced in a given year) and
- unit replacement costs.

In addition an independent database of unit costs was also established based upon other known project related costs and estimated equipment installed costs based upon supplier budget cost information. From the data provided by the companies, average

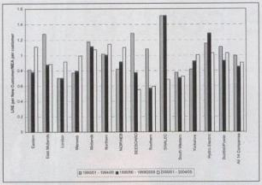

Fig 3: Normalised new business expenditure by price control period

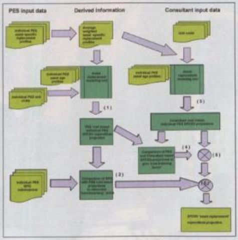

Fig 4: Asset replacement benchmarking process.

weighted replacement profiles were established for each specific asset category. These showed average lives slightly longer, if anything, than those estimated and employed by Ofgem at the previous price control review in 1994. The review of each company's expenditure was however based on its own asset age profile data.

Firstly, an 'asset replacement benchmark' factor for replacement quantities of each asset category by comparing

- a projection of expenditure based on the weighted replacement profiles and the companies' unit costs for each asset category with the
- corresponding expenditure forecast by the company.

By comparing the ratios of the expenditures for each asset category by company, median asset replacement benchmarks for quantities were obtained.

A similar comparison of replacement costs was then made between the expenditures derived from modelling using the companies' unit costs and our own unit cost database respectively. From the resulting ratios a median 'cost-indexing factor' was obtained. In so doing expenditure projections were normalised onto a common company-wide cost base which was not heavily influenced by our own cost database. The asset replacement benchmarks and costindexing factors for each asset category were then applied to the respective expenditures projected by the model in order to provide a corresponding projection of non-load related expenditure. A flow chart presentation of this "benchmarking" process is presented in Fig. 4. After due consultation with the companies and allowances made for expenditure to replace certain cable and switchgear types with particularly poor performance or safety records, Ofgem projected non-load related expenditure of US$5,0-billion against US$6,4-billion forecast by the companies.

Due to concerns that the significant reduction in allowed expenditure could result in a delayed "bow-wave" of expenditure, the benchmarking model was employed to produce a long-term projection of overall replacement expenditure which is shown in Fig. 5. This indicates a slowly rising trend influenced particularly by increasing replacement of transformers and underground cables.

Quality of supply expenditure

This expenditure is focussed on retaining or improving existing levels of 'quality of supply' (QoS), essentially the numbers and durations of supply interruptions. For the purposes of the price control review, the companies were required to declare separate investment proposals for a:

- 'Base Case' being only those investments necessary to maintain the network in its current functional condition and
- 'Quality Measures Case' combining the Base Case and specified investments for improvements to quality of supply, together with the corresponding targets for the improved performance. In the case of the DPCR3 review, rather than benchmarking company QoS proposals, a comparison of the costs and benefits of the companies' existing and future quality measure programmes to improve supply interruption performance was undertaken. The benefits were calculated in economic terms using the concept of System Customer Outage Costs (SCOC) [3], and hence provided an indication of the extent to which the programmes could

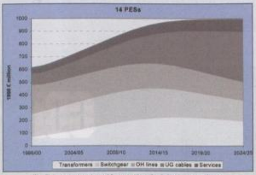

Fig 5: Long-term trend for non-load related expenditure.

be considered to be cost-justified on an absolute, rather than comparative basis.

Regulatory benchmarking overview

The work described above was essentially undertaken to assist the GB energy regulator in setting price controls for a total of 14 distribution companies. To a large extent the high level approach adopted was the result of an asymmetry of information between the regulator and the regulated businesses, with the regulator being generally considered to be the disadvantaged party.

Due to the competitive nature of independently owned distribution businesses there is often only a limited level of collaboration between individual distribution businesses. This level of secrecy arises from a degree of insecurity within such businesses when faced with potential hostile takeovers from companies which may consider themselves to be potentially better asset managers than the sitting tenants and hence able to obtain a better return on capital. In such situations it is possible for the regulator to reduce the information asymmetry by requesting comparable information from all the businesses in his area of control, and undertaking benchmarking as discussed above. By this means, the regulator can establish an approach in which the individual businesses are essentially acting to regulate each other in areas of capital and also operational expenditure.

In such situations however, the regulator may be under-funding the industry and hence placing it at risk if he does not have access to adequate information about the industry that he is regulating. The risk of under-funding arises if one or more of the regulated businesses is itself seriously under-spending due to financial weaknesses and hence delaying necessary new investment. Such a business could be seen as being super efficient, and through the use of benchmarking depriving its peers of a correct level of funding. In order to minimise distortions of this type, benchmarking was undertaken on a percentile rather than average basis. One of the ways of avoiding such a situation is by requiring companies to establish and maintain adequate network databases and to audit such databases on a regular basis. In the case of capital investment management such data bases need to include a register of all key assets, including details of their age and condition, fault rates and repair and maintenance expenditure. Other information that is needed relates to the actual life expiry information on such assets such that reliable forecasts of replacement capital expenditure can be developed, both in the shorter and also the longer term horizons. With access to reliable information of this nature, the energy regulator will be in a position to accurately monitor the health of the network and hence avoid risks to customers supplies whilst at the same time avoiding unnecessary investment.

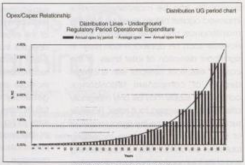

Fig. 6: Opex—age relationship.

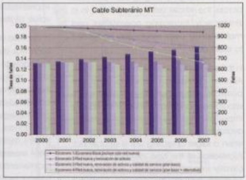

Fig. 7: Fault rate ~ asset replacement.

One of the output measures favoured by energy regulators is quality of supply, essentially continuity of supply to customers.

However, as was the case with the GB rail network, measures such as network

Asset class description	Regulatory asset life	MEA replacement cost ($M)	O & M expenditure ($M)	Average O&M (ex. O/Heads) (% RC)	% Overheads allocation	Total Average O&M (incl. O/Heads) (% RC)	% Average Planned O&M Expenditure p.a.	Initial O&M Expenditure p.a. (% RC)
Distribution substations	40	$1 060,43	$9,31	0,88%	35,00%	1,18%	30,00%	0,36%
Sub-transmission substation circuit breakers	45	$183,64	$2,51	1,37%	35,00%	1,85%	50,50%	0,93%
Zone substation circuit breakers	45	$428,48	$1,81	0,42%	35,00%	0,57%	45,40%	0,26%
Sub-transmission substation transformers & tap changers	50	$101,85	$1,13	1,11%	35,00%	1,50%	54,00%	0,81%
Zone substation transformers & tap changers	50	$233,01	$3,79	1,63%	35,00%	2,20%	47,00%	1,03%
Sub-transmission & zone substation protection & control	45	$1 024,67	$2,96	0,29%	35,00%	0,39%	62,30%	0,24%
Transmission lines - overhead	55	$379,48	$2,10	0,55%	35,00%	0,75%	36,40%	0,27%
Transmission lines - underground	45	$1 596,58	$4,83	0,30%	35,00%	0,41%	3,70%	0,02%
Distribution lines - overhead	55	$1 072,03	$35,71	3,33%	35,00%	4,50%	17,80%	0,80%
Distribution lines - underground	60	$1 635,30	$9,35	0,57%	35,00%	0,77%	3,30%	0,03%

Table 1

availability can be maintained and/or improved against historic levels by delaying maintenance and other essential works. However such an approach can result in significant disruption at later times. In the case of electrical networks with a certain degree of component redundancy, continuity of supply may be only marginally affected by increasing fault rates. However such fault rates may be the signal for a level of asset replacement. Where increasing fault rates are an indication of approaching end of life it is important that such information is not lost through averaging such fault rates across the whole asset population. In a similar way, increasing operational and maintenance costs should also be related to asset age.

In the case of the development of the South African distribution networks, and the possible aggregation of historically separately managed businesses it is equally important that the information currently available on the separate parts is not diluted when a larger operating unit is established. Information of the type identified above is clearly important to both the network operators and also the regulator. Examples of where such information can be put to good use to minimise overall network costs and/or improve quality of supply are presented below with respect to distribution networks in Australia and also in Argentina.

Capex opex trade off

Distribution networks assets include substations, transformers, overhead lines, cables and other equipment, from LV to Sub-Transmission voltages. All these assets require some level of maintenance throughout their life and the total O&M expenditure on assets can be considerable. For a network with average asset age of about 30 years, this is typically equivalent to abouth 3% per year of the MEA value. From a revenue point of view the O&M costs are equivalent to about one third of the allowance for depreciation and return on assets.

The level of maintenance of an asset varies with the age of the asset. The longer an asset is in service the greater will be the associated repair and maintenance costs, thus any capital expenditure which reduce the age of assets will also reduce the maintenance requirements. These savings are however offset by the addition of new assets to the asset base requiring additional maintenance expenditure, albeit less than that for the assets replaced.

There exists therefore a relationship between capital investment and maintenance expenditures. The extent to which the relationship can be determined is a function of the information available to the system operator. In the case of modelling that has been undertaken in Australia the relationship has been assumed to increase exponentially with age, which is generally consistent with equipment failure rates as they approach end of life, refer to Fig. 6 below. The key parameters of the model and very often the only information readily available is the average and the initial expected Operating and Maintenance expenditure expressed in terms of the replacement value of that asset category.

In the case of the referenced study, the asset base was divided into 10 asset categories. For each of these categories an average O&M spend as a percentage of the Replacement Cost of the assets was calculated as well as an initial expected O&M cost. The expenditure in each category is due to planned, corrective, and emergency (storm) maintenance, the initial expected O&M expenditure was taken to be planned maintenance cost only and as emergency (storm) maintenance is not affected by refurbishment investments it was excluded from all calculations. Typical parameters are presented in Table 1.

The major projects and programs capital expenditure for new assets and refurbishment were evaluated with regard to the expected Operating Expenditure/Savings. The findings of this analysis was a saving of about $10-million over the five year regulatory periods. This saving equates to 0,8% of the capital investment in the period and hence when expressed in terms of associated revenue allowances represents a saving of about 10%.

Clearly this sort of analysis is very dependent upon the quality of the data input however it is evident that such savings may be appreciable when expressed in terms of allowed revenue and may weigh significantly when comparing alternative network investment. It is therefore important that the relevant information is collected and collated whenever possible.

QoS – asset replacement tradeoff

An example of the possible network quality of supply benefits which may be achieved by judicious asset replacement expenditure was investigated during the course of tariff review work undertaken in Argentina. In the case of the distribution company involved, excellent network information systems were available and hence it was possible to investigate the impact of targeted investment on QoS.

In Fig. 7 a total of four underground cable replacement scenarios were investigated against a background of continuing network development. As a consequence it can be seen from the Base Case (Escenario 1) that the addition of new underground cables associated with the demand growth and the connection of new customers results in a fall in the overall fault rate.

However, if the effects of the new network plus end of life replacement of the older cable assets takes place (Escenario 2) a 25% fall in fault rate occurs. Other scenarios are also presented with varying degrees of return. If it is recognised that in Argentina significant penalties are imposed on poorly performing distribution companies, then it is clearly important for the company to be in a position to undertake such analysis in a robust way such that it can influence the regulator with respect to the appropriateness or otherwise of such penalties, or conversely to determine for its own internal purposes the consequence of certain courses of action. The importance of retaining and enhancing network information with respect to issues such as age related equipment fault rates is clearly evident.

Summary

It is evident from the work presented above that knowledge of the distribution network is one of the most important issues associated with the management and development of the network. Similarly such knowledge is also important to the efficient regulation of the network and as a safeguard against serious degradation of supply quality with associated adverse impact on customer comfort and safety and also economic development. The extent to which such network information is disaggregated is also important and, at times of rapidly changing network structure and organisation it is important that historic data is not lost or aggregated into a form that prevents its full usage.

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Practical problems with substation earthing

by Dr. Hendri Geldenhuys and Craig Clark, Eskom Distribution Technology

This paper considers the issues around substation sites where the soil resistivity is of particularly poor quality and makes it particularly difficult to achieve a safe installation. The issues will be examined around Eskom's planned Wonderkop substation which sits on the Bushveld Igneous Complex where the earth resistivity is very high.

Objectives of substation earth electrode design

Safety of utility staff and workers of incidentally connected plant

Substation earthing plays a vital role in the safety of the environment when a phase to ground faults occurs in or close to the substation. This impact on the safety of staff inside the substation as well as the safety of staff of substations and the factories of customers connected to the faulting substation. In addition it affects the safety of the public that are in the vicinity of the substation and may even have an effect on the safety of public services in the vicinity of the substation where incidental connections exist between the substation earth and the public service.

In order to ensure a safe installation, the step and touch potentials around a substation are designed according to the IEC and IEEE standards [1], [2], [3]. This design broadly aim to limit the current that would go through the body of a person exposed to such a ground potential rise to within the limits of the IEC criteria that is given in Fig. 1B.

In addition to ensuring safe step, touch and transferred potential to persons, the Eskom standard [1] required that the ground potential rise is limited to 5000 V. This is related to the protection of services such as telephone lines that run external to the substation to be adequately protected [4].

To achieve these design objectives it is normally required to achieve a very low earth electrode resistance at a substation (less than 1Ω). For example in a substation with a phase to ground fault level an earth electrode resistance of 0,5 Ω is required.

Lightning protection

The lightning protection of a substation does not depend on reaching a magical (low) earth resistance value. In fact very low earth resistance values in the networks is known to cause the failure of surge arresters due to the majority of lightning current passing to ground at that point and eventually exceeding the energy rating of the arrester. When an arrester has failed it leaves the plant it was protecting vulnerable till it is replaced.

Successful lightning protection require that surge arresters are placed in the correct positions in the substation, which include all points where lines exit or enter the substation, and in addition to ensure that the travelling wave phenomena and effects of inductance of earth tails of arresters are taken into consideration. This may required for example that arresters are installed on the bushings of transformers as well, etc. It requires that the bonding of arresters and equipment to the earth grid is designed and done with care.

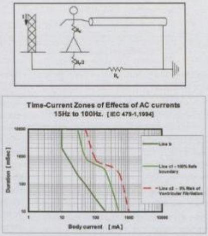

Fig. 1A and 1B: The basic approach to modelling transferred potential from IEEE 80 and the safe current criteria from IEC 479-1 which has to used to determine safe conditions for staff and public exposure to ground potential rise caused by faults in the power network.

Earth resistivity and electrode resistance of the Wonderkop substation

Fig. 2 shows the earth resistivity measurement at Wonderkop substation. Geologically it is known that the site has a surface clay layer of around 1 to 2 m thick. This sit on top of the Bushveld Ingenious Complex strata which are 100s of metres thick in the area. If the resistivity measurement is converted to a two layer resistivity model with CDACS the results does not converge nicely. The results gives quite large variations in layer thickness and resistivity, especially that of the deep layer. This is due to the large difference in resistivity between the two layers. It is believed to be an underestimate of the actual resistance if a top layer of 3 m with a resistivity of 300 Ω.m and a deep layer resistivity of 10 000 Ω.m are assumed.

The substation design footprint is 80 x 60 m with ten trench conductors parallel to the length and 15 parallel to the width buried at a depth of 1m. The resultant electrode resistance calculated with CDACS is 22,3 Ω. The resultant ground potential rise profile result from CEDACS is shown in Fig. 3.

The result raises the question how such a high value of resistance could be lowered. One option would be to enlarge the

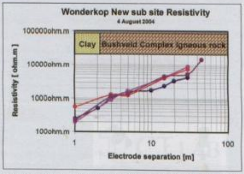

Fig. 2: The resistivity measured at Wonderkop planned substation site.

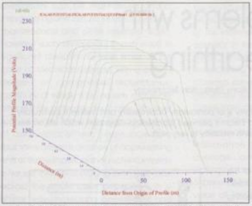

Fig. 3: The GPR calculated with CDACS injecting a fault current of 10 kA into the substation grid electrode.

substation and to bury much more copper in the substation: For example by increasing the footprint of the sub to 160 x 120 m and installing 19 by 29 conductors in the ground. This improves the resistance only to 15 Ω. It is well known that under these conditions little can be done to improve the resistance of the station and other options has to be exposed.

An alternative possible solution is to treat the soil around the electrode by means of a salt such as gypsum or inbed the electrode into bentonite. The effect of the salt or bentonite is only around the electode itself, very localised. It may improve seasonal variation of resistivity close to the electrode, however it does not change the resistivity of the deeper strata and thus leaves the electode resistance just marginally better than without the treatment. The value of the resistance has to be better than one ohm which will not be achieved.

Modelling the ground potential rise on the Wonderkop earth electrode

A model for the Wonderkop single phase to ground fault was established, this is shown in Fig. 4.

The distance between the main transmission substation and the Wonderkop substation is only 900 m. With the poor earthing conditions in the area the footing resistance of tower in the area is estimated to be at best around 100 Ω and most likely worse. For this reason the tower footing resistances was ignored in the modelling.

The impedances of the conductors, shield wires and the transformers had to be established. This presented its own problems as classical calculation of some of these parameters; especially the earth return part and impedance do not follow classic assumptions, which is a good connection between the substation earth and the body of the earth. Some assumptions had to be made to compensate for this.

The phase conductors on the line are Kingbird and two 132 kV lines run between the two substations. It should be noted that the return current in the case of a phase to ground fault may not necessarily return equally via both interconnecting lines. This can only happen if the coupling breaker between the bus bars of both lines is closed. The fault current can then be fed into the substation via both lines and the impedance of the fault in this case would see the zero sequence impedance of both lines in parallel. In the case where the breaker coupling the lines is open, fault current will only be fed via one of the lines. The shield wires of the not faulting line will be in the circuit but the inductance in that circuit will be that of the faulting line phase conductor relative to the non faulting line's shield wire. Clearly this inductance/ impedance is relatively very high.

The calculation of the GPR of a single phase to ground fault at the substation using standard 19/2,64 steel wire shielding wires is a voltage rise of 12,2 kV. This is clearly way above the design targets. One possible solution for this particular problem is to use a much more conductive shield wire. Instead of using a steel shield wire a conductor such as hare can be used.

The result of such an approach is shown in Fig. 5.

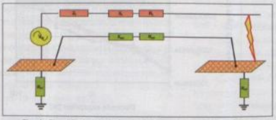

Fig. 4: Simplified model of a single phase to ground fault in the Wonderkop substation.

Using a Hare conductor as shield wire compared to a normal 2,65/19 steel wire with a resistance of 1,85 Ω/km reduces the GPR from 12 kV down to around 5 kV, which is within the design limit set by Eskom's standard.

It can be noted that if the bus coupler at the sub is run closed there is a marginal improvement in the GPR because of both lines taking part in returning the current to the feeding substation.

Transferred ground potential rise to customer substation and plant as well as to other services

In substations where customers are fed from overhead MV lines customer earth electrodes are decoupled from the utility substation earth electrode because there is simply not any direct galvanic connection. MV lines normally does not have shield wires and even if there were shield wires the design of the MV-LV transformer installation is specifically done to prevent the transfer of fault GPR to customers. Eskom maintains an insulation level of 5 kV rms from the MV earth electrode to the customer LV earth electrode. This implies that normally substation GPR will not be transferred in the case of LV fed customers.

Fig. 6 illustrates one of the potential hazardous situations that substation designers have to avoid. When services such as telephone connections that are shared by other customers are directly connected to a substation it pose a potential thread to the customers on the service.

This situation can be avoided by inserting isolation interfaces between the external connection to the substation and the substation.

In the case of telephone systems both optic fibre as well as radio based systems is available to fulfil such a function. These systems price tags are short of R100 000 and can be used in cases where data transfer on the system are required. Optic fibre units are also available at much lower cost in the case where dedicated data channels are to be connected such as RS 232, 422 and 485.

A much more difficult situation to deal with is the case where customers that receive power directly from the utility substation at MV voltage and have their own substations from where they transform and distribute power directly to their plant. In most of these cases it is not possible to decouple the customer's installation from Eskom's substation earth grid and GPR. It is very difficult or impossible to separate these earth electrodes as cables with armouring interconnect the systems and the substations are often so close to each other that even if it were disconnected by some means the GPR will still be transferred by means of coupling through the ground. One relieving

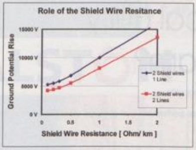

Fig. 5: The ground potential rise due to a single phase to ground fault versus the shield wire resistance for different line configurations.

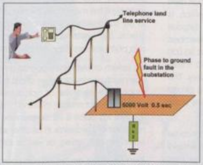

Fig. 6: An illustration of transferring GPR via shared telephone services to telephone subscribers.

benefit of this situation is that the net earth electrode resistance is lowered in this case by the parallel connection between the earth electrodes of the utility, the customer substation and any incidental electrodes that the customer may have in his plant.

In this case it is imperative to either separate the customer earth or for the customer to maintain similar step and touch potential design principles that are used in designing power substation in his own plant. Separation MV and LV earth electrodes in many cases are not possible for example in the case where MV motors are used in the plant. In this case interconnection of the MV and LV earth is a basic requirement.

Conclusion

The design of substation earthing require attention to detail of plant and services connected to it. In the case where customers take supply at MV or HV from the supply authority careful consideration has to be given to the transfer of GPR under fault conditions to avoid dangerous situations to the public, customer staff and utility staff.

Acknowledgement

The CDACS calculations have been done by Enderani Naicker with the support of Tony Auditore both from Eskom Transmission Technology.

References

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[2] IEEE Std 80-2000 IEEE Guide for Safety in AC Substations Grounding.

[3] IEC 60479-1

[4] IEEE Std 487-2000 IEEE Recommended Practice for the Protection of Wire-Line Communication Facilities Serving Electric Supply Locations Δ

Fault free electrical utility: reality or dream?

by Dragan Vujovic, Umtshezi Municipality

Intention of this paper (case study) is to analyze number of factors which influence performance of average electrical utility in present South African condition.

We are constantly hearing about problems with regards to the quality of electrical supply. These include regular interruptions, lack of maintenance, etc. Prof. Anton Eberhard, a member of the NER board, in a recent issue of ENERGIZE Journal quoted the following:

"Some areas in South Africa are already experiencing not infrequent interruptions in supply. This is mainly the consequence of municipalities not investing in adequate maintenance or strengthening of their distribution network".

But there is also another side to this story, which we want to share with you.

What would you think if you were told that a municipality exists which does not have the above problems? Where there are no backlogs in new connections; where upgrades, refurbishment and preventative maintenance are fully in place; where there are no rotten poles with dirty or broken street light shades, etc.

Why is the electricity set-up in Umtshezi Municipality different, and why is it appropriate for it to be described here?

Firstly, Umtshezi represents an average electrical utility in almost every aspect. Estcourt is a typical industrial average-size town, with a ratio of 67 % industrial load, 13 % commercial and 20 % domestic load which is probably very close to the ratio of the categories of load profile in the country. Secondly, we are the 37th load size municipality in the country - not big but also not small - with an average load close to 40 MVA.

And the last very important matter, is that we are part of a municipality with all the many problems which every municipality faces, in regards to budgetary constraints, staffing, bureaucracy, etc.

What makes it interesting is how we manage to have successful electrical utility while being average in almost every aspect. Therefore, I would like to initiate some interaction and share experiences of what we are doing on a regular basis to provide a reliable electrical supply. I hope this information will prove to be beneficial for others.

Lessons learnt

The electricity system in Umtshezi Municipality consists of Estcourt's urban area and the Wembezi township which is approximately 8 km from Estcourt. Estcourt is mostly an industrial town, while Wembezi township has 3 500 households and 30 000 people, using approximately 2,0 to 2,5 MVA in summer and winter respectively. The electricity system in Estcourt town is almost fully cabled while Wembezi is mostly done by means of overhead lines.

Every utility has a history with a lesson to be learnt. So do we on becoming a Transitional Local Council in around 1995, we took over Wembezi town. Due to the fact that no maintenance was done on the electrical system during the period of years of political violence, no one wanted to take over the electricity service at this township. However, we were consistently paying an Eskom bill, which at that time was averaging over R250 000 for slightly over 1 000 connections on a flat rate.

The main challenge at that time was the resistance of the staff to tackle the new problems, and the council not being flexible enough to address the problems. Electricity service was the last one to be taken over by council from the KwaZulu Natal Provincial Administration, which took place in 1998. My first task after appointment was to undertake the refurbishment of the network, including an electrification project during 1998 - 1999. The total cost of the project was R6,3-million and was funded mostly by council and partly by NER via their electrification programme. The project included the installation of prepaid meters for old and the new installation and total refurbishment of the network.

So, what are the results? Since then the system has been operating well with regular maintenance in place and no occurrences of tampering, etc. After six years the present Eskom bill is by far lower than the one prior to refurbishment, despite the fact that we now have three times more connections and have had five annual Eskom increases.

Although we inherited problems in Wembezi, we needed to realize that it was still our problem, and the more we delayed rectifying it, the more costly it would become to do so, besides all the other negative effects. The lesson learnt here is universal, and past mistakes must not be repeated.

The system at Wembezi is operating well, but how much money could we afford to spend if places like Wembezi, as typical residential areas, needed millions of Rand? I can tell you that this place is still experiencing major non-payment problems in all other services: water, sewage, refuse, as well as rates.

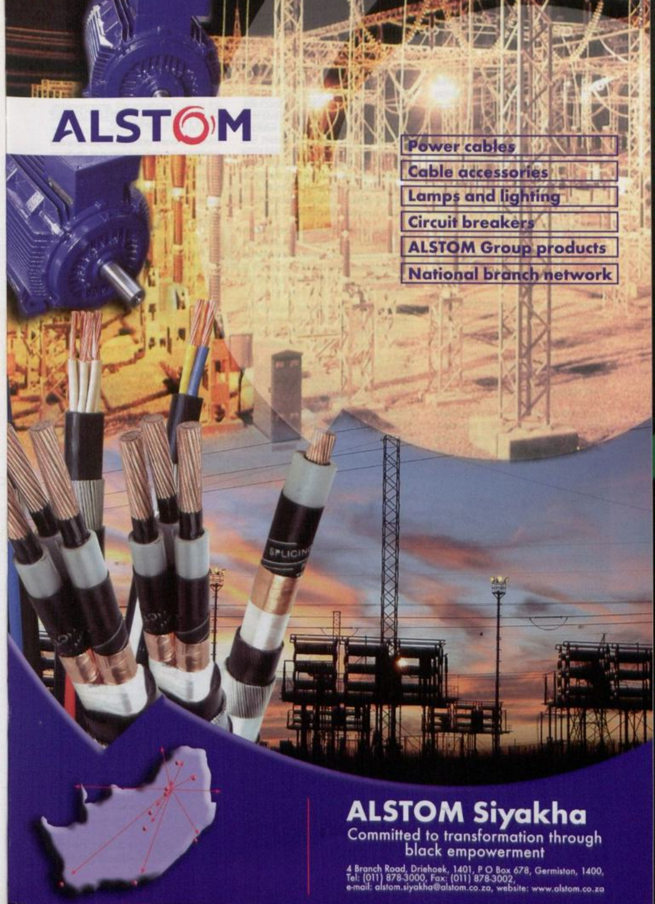
Therefore, there are two ways to upgrade an electrical system to a good functional operating level. Firstly, as in the previous example, to use large capital funding, or secondly, to do it systematically over a period of years. In some instances, we can manage to access funding to completely refurbish the system, but often this is not possible.

Planning

To achieve the best results it is necessary to systematically address problems in the system. One needs to have a good plan, and the best way is to have a good long term plan, for example a five year master or electricity plan. This is normally done by consultants. I did a couple of presentations a few years back showing how a relatively small municipality can solve this problem in-house, by having the right tools (a number of software programs), and the ability to do full planning, basically on its own. One needs to acknowledge that no one knows our systems better than we do. Having the correct tools, the engineer is able to simulate IF scenarios and make the most appropriate and cost viable decisions, and ultimately prioritize projects. Knowing each year what we need to do with the available funds makes work easier. Master plans need to be part of the municipal IDP as this covers capital projects, strengthening of the network and future upgrades, etc.

What we have done is measured in years. There has been no quick fix.

Buying new equipment as part of capital projects is actually the first step to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excellence. We opted for new technology a number of years back. Besides a number of other benefits, it reduces or completely eliminates maintenance. A few years ago, we started an upgrade of ring main units in the industrial area as part of our secondary medium voltage system in town using new SF6 ring main units. But we had to halt this for a while, as the rate of exchange at one time was not favorable. But things have changed recently, and we have completed the project and our whole industrial area is now covered by new equipment. We also replaced numbers of medium voltage panels in our main substations, where in some instances equipment was more than 50 years old. Although well maintained, we had no option but to replace it to ensure a good quality supply.

Do you have a detailed master or long term electricity plan? How are your capital projects executed? What standards are used when new equipment is acquired?

Preventative maintenance

Having worked in industry for a numbers of years where preventative maintenance is a necessity, it was natural for me that such principles should also be applied in municipal utilities. We all have programs of that nature, but often these seem to not work well. And so, we need to ask why? We used to patrol lines only when the circuit breaker trips. Now we do it every month as part of our programme. Regular inspection of equipment, even visually, can prevent the occurrence of serious problems. It is amazing that even staff on lower levels, adequately trained, are able to come forward with valuable information about possible problems in the system. We have about 30 regular inspection schedules which are very simple. These cover most of the equipment, starting from patrolling the line, substation inspections, substation battery checks etc.

The higher the technical complexity of equipment, the higher the level of staff is involved. For example, certain senior staff in department are personally responsible for main substations in the system. The frequency of these inspections is the crucial link to the prevention of faults.

Besides visual checks, we have introduced a number of other tests such as:

- Pressure tests of equipment (biannually)
- Circuit breaker and protection tests (biannually)
- Transformer oil tests (annually and on main transformers 6-monthly)
- Load and voltage tests (annually)
- Infrared tests (annually)
- Poles for rottenness (biannually)
- Meter tests (biannually)

It is essential to regularly do all available tests, which your department is able of performing. Those which you cannot manage can be outsourced to specialists. Pressure testing of equipment takes time and lots of switching. Last year we tested all medium voltage cables in our system, and it is amazing what we found. We have redone many cable joints to prevent future problems. We are confident that cables are in order now, and have also identified which ones we need to look at carefully and possibly replace in the future.

We prefer protection tests to be done by specialists in conjunction with circuit breaker testing. Everyone who has done this exercise will be surprised how much is involved to ensure that you have a well-protected system in place.

Infrared tests are a typical preventative maintenance tool. We do these annually on the full medium voltage system including also low voltage panels in substations; this takes days but it is worthwhile and tremendously helpful. We prefer to perform transformer oil tests, rather than just regularly purifying the transformers.

Load and voltage tests are done by means of ammeter reading or preferably using loggers. We have over a period of years obtained a quantity of loggers which we installed in substations, in order to have a full load profile. The result is that in the winter period we have a balanced load, and we have practically no call outs during winter. And some of you know how cold Estcourt can be!

Do you have a maintenance program in place and is it implemented fully (frequency of inspection and test)?

Refurbishment plan

We found that in order to save money, there are lots of ways to replace essential parts of equipment and basically extend the life of our equipment. Everywhere possible, we replaced:

- Medium voltage circuit breakers with upgraded ones
- Every electromechanical relay with an electronic one,
- Amount of medium voltage circuit transformers,
- Old battery tripping units,
- Every bare low voltage overhead line in town with aerial bundle conductor,
- Every box in the CBD area with a concrete one,
- Street lighting in town has been completely refurbished.

The refurbishment of equipment is probably where the municipal engineer is most challenged, as funding is always limited. All of above are done in a well-planned manner, taking into consideration future requirements, increased demand, etc.

Do you have a refurbishment plan in place and is it fully implemented?

Common to any of the plans above, is that funding and staff are needed. Being a municipality we never expected to have a significant allocation of funds to the electricity department. But it has always been steady over the years .

Altogether what are the results?

- No problems in the system
- The amount of breakdowns has been minimized to almost non-existent
- Planned work is our main objective which in turn reduces the amount of breakdowns in the future.

These are all the relevant events which occurred from 1 January 2002 covering almost three years:

- Three 100 kVA transformers, two at the township and another at a rural line, were blown by lightning. In all cases protection operated correctly. Transformers were replaced on the same day.
- MV cable in a residential area of town damaged by contractor. Protection operated correctly. Power restored in 45 minutes. The SMS system which we introduced a few years ago facilitated a quick response as all senior staff attended to this fault.
- Two MV cables supplying the main water works simultaneously hit by a lightning strike. Protection operated correctly. Power to the water works was restored on the same day.
- Eskom power failure causing 3 hours interruption of whole town, (blown VT's on their 88 kV substation).
- Rural line Mimosadale tripped on two occasions due to the weather conditions. Protection operated correctly. Power was restored on the same day.

As you are able to see, all of the above events (besides the Eskom failure) are minor incidents affecting limited areas for a short period of time.

The main achievements of all our programmes and efforts are that:

- The prevention of every fault was beyond our power
- Protection on all occasions operated correctly
- Business and industry have not been affected except in the case of the Eskom fault
- No other failures of equipment

Engineer's role

This is just one side of the story, the other side relates to the human aspect: how committed our staff are, how far everyone is prepared to go, how enthusiastic we are, and the pride we take in our work and achievements. The engineer's role in this whole process is probably one of the most important as he is the driver of the entire process. This is particularly important for the engineer in a medium sized municipality, as he is the person involved in management, planning, technical aspects, administration, operations, etc. Municipal engineers must not forget that we are in the first instance engineers, and that maintaining and upgrading our system is priority number one.

The municipal engineer has to be resourceful and undeterred by bureaucratic problems and blockages in his day to day workings. Creative ways are needed to resolve problems and overcome obstacles. The engineer must continually be finding ways to fund projects and must follow every avenue to make things happen in his department. He should always be adaptable and willing to prove to council and his community that he is doing all he can to improve their lives by providing for their energy needs. Always strive towards perfection, and do not settle for mediocrity. Electricity is the life-blood of both the economic and residential communities within a municipality, and it must be afforded the importance it deserves.

The same will apply to senior staff of the department. The experience of senior staff is essential to the staff on the site. Make sure that your senior staff spend a considerable amount of time on site. A good management team is the formula for success - a team which is willing and able to go the extra mile. They must all be willing to be available immediately for any problem, even if not on stand-by duty. All it takes is one phone call!

Assisting council by going out of our way is another aspect of our work. Being able to deliver service quickly and effectively is highly appreciated by the council. This is particularly important in remote rural areas where access to electricity completely changes the life of the communities. Making sure that there is no backlog, and being proactive are some of the reasons why we always have support from our council.

Prof. Anton Eberhard comments in ENERGIZE journal by saying: "And one of the reasons they have not done so has been the uncertainty regarding the transfer of their assets into the envisaged six regional electricity distributor (RED) companies."

Years ago we convinced council that it is in their best interest not to stop spending in the electrical system for two reasons:

- If everything goes well during the take-over period, the value of their shares in the new company will be increased,
- In all instances even if something goes wrong, the municipal system will still be in such a condition to last for a number of years and provide quality supply to community.

This approach, after a number of years of uncertainty in regards to the restructuring of ESI, has shown great results. Our aim is not to join Regional Electricity Distributor to solve our problems, but simply to bring one problem less to the table!

Conclusion

It is probably not possible to have an entirely fault free electrical utility, as we depend on a number of factors which are sometimes beyond our influence. But a combined systematic and holistic approach, backed with technical knowledge and extra effort, can make a significant difference.

Thanks to my dedicated staff and to our council for their continued support. Δ

Network reliability in South Africa and its allignment with international practices

by Baden Chatterton, Eskom Distribution Technology

The electricity supply industry (ESI) of South Africa is set to undergo a fundamental change over the next few years. The main driver is the restructuring of the electricity distribution industry (EDI), with the integration of the local municipalities and Eskom Distribution Division into the six Regional Electricity Distributors (REDs).

The electricity customers in the REDs will have concerns about two basic critical issues:

- the price of electricity (and the annual increase) and
- the reliability and quality of electricity supply received.

Both of these two customer concerns will provide challenges to the future REDs. The National Energy Regulator (NER) will be required to effectively regulate these two customer issues in South Africa.

It will be expected that the REDs will achieve improvement in business performance over time due to the economies of scale, enhanced business efficiencies, improved operational processes, improved governance and the presence of competitors.

There is an expectation that the reliability of electrical supply will also improve when regulatory incentives are fully implemented in South Africa and REDs in the future. Experiences in the United Kingdom (UK) after electricity privatisation, show a 38% improvement in customer minutes lost and an 8% improvement in the frequency of interruptions (measured on a ten year rolling average) from 1986 to 2000. In the New South Wales and Victoria states of Australia, the customer minutes lost improved by 24% and 64% respectively [1].

Similar network reliability improvements were experienced in Italy when regulatory incentives were introduced. There was a 43% improvement in the average interruption duration and a 30% improvement of the average frequency of interruptions over 3 years [2].

Outline of paper

This paper deals directly with the network reliability - the interruption performance - that will affect the future EDI. The approach and methodology of measurement, reporting and benchmarking are discussed and key issues are addressed.

The relevant international standards and practices will be discussed with the focus on sharing information about practices in the Eskom Distribution Division. A high level network reliability comparison of international utilities is provided.

The lessons learnt by Eskom Distribution will be discussed. The information will be applicable to all the municipalities and will be of direct use and benefit to all the AMEU members.

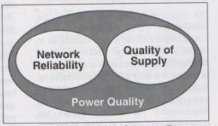

Fig. 1: The components of power quality

Power quality

Power quality comprises of quality of supply (QOS) and network reliability as shown in Fig. 1. In other words, power quality is the measure of the quality of the voltage waveform received by the customer and measures the reliability of the received voltage waveform.

QOS deals with voltage waveform quality and uses metrics such as voltage dips (X, Y, Z, T and S class), regulation, harmonics, flicker and unbalance. Network reliability (as per Eskom Distribution and IEEE definitions) deals with the frequency and duration of network interruptions (or outages). These can be sustained interruptions (long) or momentary interruptions (short) for the network or the individual customers.

In Eskom Distribution, this is refered to as network interruption performance (NIP) because the network interruption performance measures three key components:

- Reliability (frequency of related metrics)
- Availability (duration related metrics)
- Security of supply (under frequency load shedding related metrics).

Distribution and transmission network reliability indices

The two basic categories of network reliability indices are customer-based indices and load-based indices. Customer-based indices record the frequency and duration of interruptions for individual customers. Load-based indices record the frequency and duration of interruptions of loads.

The transmission network reliability indices are not all internationally standard and can vary from one transmission utility to another. This is due to the difference in interpretation of concepts such as delivery points and reception points, the difference in operating scenarios (back feeding options, load status and interconnectivity) and the voluntary and involuntary load reductions. The distribution indices are more internationally standard and consistent amongst the distribution utilities, but difference in interpretation does exist (especially on the "finer details" of reporting).

The advantages of the network reliability key performance indicators (KPI) are :

- Forecasting and trend analysis on the network performance allowing appropriate performance improvement plans to be implemented.
- Evaluating predicted performance against actual performance, introducing sustainable (long term) performance levels to the electrical utility.
- Appropriate performance target setting and incentive based regulation and monitoring
- Ability to compare customer expectations and experiences against the actual performance (measured).

Network reliability standards

The American Institute of Electrical and Electronics Engineers (IEEE) working group (WG) on system design (15.06.02) has compiled the P1366-2003 standard "IEEE guide for electric power distribution reliability indices", that provides the network reliability measurement methodology and reporting requirements of the IEEE [3].

The international IEEE task force on outage reporting practises (under the custodianship of the IEEE WG on system design) is busy drafting a standard that will provide information regarding data collection, validation, storage, and reporting practices related to interruptions and outages affecting electric power distribution systems. Eskom Distribution is represented on the task force.

The International Electrotechnical Commission (IEC) standards on power quality have been grouped under the broader set of the EMC (electromagnetic compatibility) standard IEC-61000. Although not focused on interruption performance directly, the IEC standard (and associated technical reports) forms a starting point in the discussion on transmission voltage targets (defined as planning levels in the standard).

The European technical standard EN 50160 provides definitions on short and long interruptions.

The existing NRS 047 (electricity supply quality of service) and NRS 048-2 (MV and LV quality of supply requirements) are not network reliability standards but do provide the minimum performance requirements for planned and forced interruptions and for the restoration times of supply after a forced interruption. The definition of network reliability for the purposes of statistical system performance reporting will be defined separately by the NER.

Eskom Distribution has recently published its own standard (DISASACT3) "distribution network performance KPI definitions standard". The Eskom standard aligns with the IEEE P1366 document; revises the existing network reliability indices; "cleans up" certain existing definitions and introduces a set of new reliability indices for Eskom Distribution [4].

The implementation of this standard on existing Eskom systems and database is currently being reviewed due to the potential purchase of the outage management (OM) product of a distribution management system (DMS) vendor.

Overview of distribution network reliability indices

The following summary information is based on the measurement and reporting methodology applied in Eskom Distribution. The intention is share the application of network reliability measurement and reporting and the difficulties that can be experienced in the actual implementation. These difficulties stretch from paper definition and formulas to working software systems and databases in a large and complex utility.

Medium and high voltage categories for reliability reporting

For network reliability reporting purposes the following voltage group definitions are used in Eskom Distribution :

Medium voltage (MV) will be regarded as network voltage levels of 11 kV, 22 kV and 33 kV. This also includes the "odd" 1,73 kV, 2,2 kV, 3,3 kV, 6,6 kV networks in Eskom.

High voltage (HV) will be regarded as network voltage levels 44 kV, 66 kV, 88 kV and 132 kV. The 44 kV networks are regarded as HV due to their HV related design characteristics and application as a distribution voltage in Eskom Distribution.

Internationally MV networks are generally classified in the voltage range of 1-35 kV. SANS 1019 does specify MV ±44 kV, but also lists 44 kV under range B with the other HV classified voltages. Eskom Distribution (B. Chatterton) has made representation to have the 44kV networks moved into the HV category of networks in the NRS 048 standards.

Network interruption definitions

In Eskom Distribution a sustained network interruption (or loosely referred to as an outage) is a network event for which electrical supply was off for 2 minutes or longer. This 2 minute time window applies to medium voltage (MV) and high voltage (HV) networks. It is required that there be a 100% loss of voltage on the affected phase. The NRS 048-2 defines an interruption in terms of the disconnection of the supply point. In Eskom Distribution the outage is either recorded accurately via the supervisory control and data acquisition (SCADA) system, or via manual validation and auditing paper operating logs from the field staff.

An outage is usually referred to in terms of the state of a component that is not available to perform its intended function due to some event directly associated with that component.

A momentary interruption (short event) is an event less than 2 minutes. The momentary interruption can be the auto-reclose (ARC) operation of a circuit breaker and a 100% voltage loss on the phase is assumed. These momentary interruptions are reported separately and excluded from the sustained interruption reliability index calculations.

The primary network interruption is called the event and the associated network operation due to fault finding or switching is called a state change. On average an event can consist of 2 to 5 associated state changes (depending on the nature and complexity of the event). The state changes are counted in the reliability indices, if their duration is equal to or longer than 2 minutes. This detailed practice does tend to "penalise" Eskom Distribution in network reliability benchmark exercises.

Eskom Distribution will be changing the sustained interruption time window to 5 minutes for MV networks to align with the IEEE P1366 standard. In some cases automatic switching operations (actual performance) on MV networks do not get completed for several minutes and extending the window out to five minutes will also more accurately classify sustained MV interruptions. This time requirement also differentiates between the automatic (system) and manual (operator) intervention to restore network supply to the customer.

The sustained interruption time for HV networks is proposed to be reduced to one minute to align with Eskom Transmission practices, but may have to be reviewed and maintained at two minutes due to the potential telecontrol constraints. (One minute classification is commonly used internationally by transmission utilities.)

These Eskom Distribution definitions align with the NRS 048 definition of a forced interruption and with the subsequent classification into sustained and momentary interruptions.

Planned and forced interruptions

NRS 048-1 provides the definitions of planned and forced (unplanned) interruptions. In the Eskom Distribution context, forced interruptions are loosely referred to as "faults". The sustained interruptions can then be broken down into their planned and unplanned components. The planned interruptions are regarded as controllable events and the unplanned interruptions as uncontrollable events.

A planned interruption is the loss of supply that results from a component deliberately being taken out of service at a selected time, usually for the purposes of construction, preventative maintenance or repair.

A forced interruption, is the loss of supply that results when a component is taken out of service immediately, either automatically or as soon as switching operations can be performed, as a direct result of emergency conditions, or an interruption that is caused by improper operation of equipment or human error.

In Eskom Distribution the planned and unplanned interruption categories are time based and depend on the amount of notification time about the pending loss of supply that was provided to the customer.

Where possible the customer should be given at least 48 hours advance notification before any planned interruption.

Customer voluntary load reduction events are characterised by the curtailment, partial curtailment, or reduction of customer load. These are not regarded as "pure" network interruptions and are included as part of the network reliability indices. These events are measured and reported separately using the under frequency load shedding (UFLS) metrics.

Sustained interruption indices

The following are the key sustained interruption indices used and their definitions.

SAIFI (system average interruption frequency index): The SAIFI of a network indicates how often, on average the customer connected would experience a sustained interruption per annum. Mathematically SAIFI can be expressed as:

$$SAIFI = \frac{\text{Total number of customer interruptions p.a.}}{\text{Total number of customers served}}$$

CAIFI (customer average interruption frequency index): The CAIFI of a network indicates how often, on average only the customers affected by an interruption, experience a sustained interruption per annum. The customer is counted only once in this calculation regardless of the number of times interrupted. This index differs from SAIFI in that only the number of customer interruptions is used in the denominator and not all the customers connected. Mathematically CAIFI can be expressed as:

$$CAIFI = \frac{\text{Total number of customer interruptions p.a.}}{\text{Total number of customers interrupted}}$$

SAIDI (system average interruption duration index): The SAIDI of a network indicates the average duration of a sustained interruption the customer would experience per annum. It is commonly measured in customer minutes or customer hours of interruption. Mathematically SAIDI can be expressed as :

$$SAIDI = \frac{\Sigma\text{customer interruption durations p.a.}}{\text{Total number of customers served}}$$

CAIDI (customer average interruption duration index): The CAIDI of a network indicates the average duration of a sustained interruption that only the customers affected would experience per annum. It is commonly measured in customer minutes or customer hours of interruption.

This index differs from SAIDI in that only the total number of customer interruptions is used in the denominator and not all the customers served. Mathematically CAIDI can be expressed as either :

$$CAIDI = \frac{\Sigma\text{customer interruption durations p.a.}}{\text{Total number of customers interruptions}}$$

CAIDI is also the ratio of SAIDI and SAIFI and can be expressed as ;

$$CAIDI = \frac{SAIDI}{SAIFI}$$

SAIDE = CAIDI x SAIFI

The general case is for CAIDI < SAIDI, as CAIDI only takes into account the number of effected customers.

The network reliability indices SAIDI and CAIDI measure the availability of supply. The duration of interruptions SAIFI and CAIFI are indices that measure the reliability, the frequency of interruptions, of the electrical supply. The indices can be broken down into their planned and unplanned components for detailed analysis.

CAIFI is very useful when a given calendar year is compared with other calendar years. In any given calendar year, not all the customers will be affected. CAIFI can be used in recognising chronological trends in the reliability of a distribution system.

The European convention is to refer to SAIDI as customer minutes lost (CML) and SAIFI as customer interruptions (CI).

Momentary interruption indices

The following are the key momentary interruption indices used and their definitions.

MAIFI (momentary average interruption frequency index) : The MAIFI of a network indicates how often on average the customers served would experience a momentary interruption (MI) per annum. Mathematically MAIFI can be expressed as:

$$MAIFI = \frac{\text{Total number of customer MI p.a.}}{\text{Total number of customers served}}$$

MAIFIe (momentary average interruption frequency index of events): The MAIFIe of a network indicates how often on average (frequency) the customers connected would experience a momentary event per annum.

If two or more breaker reclose operations (ARCs) or momentary interruptions occur, within the relevant window period for the HV and MV definitions, then these interruptions will be considered as part of the momentary event and will only be recorded as a single momentary event. Mathematically MAIFIe can be expressed as:

$$MAIFIe = \frac{\text{Total number of customer MI events p.a}}{\text{Total number of customers served}}$$

Eskom internal reliability indices

In Eskom Distribution there are internally reported indices that measure the transformer availability (only accounting for Distribution caused interruptions). There are also internal indices that are a modified form of SAIDI and SAIFI for the field work staff.

HSLI (HV supply loss index): The HSLI of a network indicates the monthly average network loss duration by the HV plant installed due to sustained interruptions caused only by Distribution. It is a measure of the HV transformer availability and is expressed as hours per month. The HSLI will also include HV plants that have been affected by MV related through faults on the network. Mathematically HSLI can be expressed as :

$$HSLI = \frac{\Sigma\text{MVA.Hourslost per month}}{\text{Installed HV MVA base}}$$

MSLI (MV supply loss index): The MSLI of a network indicates the average network loss duration by the MV and LV plant installed due to sustained interruptions caused only by Distribution per month. MSLI is mathematically similar to HSLI but with the MV transformers and MV related MVA used in the equation.

The SAIDI-N and SAIFI-N are reliability indices of the network. The "N" represents network. These are similar to the SAIFI, and SAIDI indices except the numerator only includes the events and not the associated state changes due to switching and fault finding and the denominator is the total number of installed transformers and not the total served customers on the network.

The state change fluctuations do not accurately reflect the level of "network performance" but do reflect the level of "customer reliability experienced". The customer is more interested in that he had an interruption (customer reliability) and lost supply than that 5 successive operations occurred while fault finding (network performance). The fault finding is irrelevant as the customer is without supply anyway. From a network performance perspective, it is the event that is important and not the number of state changes. The field work may feel that they should rather be compacted on SAIFI-N and SAIDI-N.

Major events

A major event (ME) is an event that exceeds the reasonable design or the operational limits of the electrical network.

The IEEE P1366 standard proposes that a statistical approach is used (Beta Method)

Category of network	Planned Interruptions		Forced Interruptions	
	Number	Total duration	Number	Total duration
Residential established	2	6	6	12
Rural overhead (≤ 22 kV)	N/A	N/A	60	200

Table 1: Summary of the frequency and duration of sustained interruptions for overhead networks (taken from Annex B NRS 047)

to identify major event days (MEDs). The purpose of this statistical approach is to allow major events to be studied separately from daily normal operation and in the process, to better reveal trends in daily operation that would be hidden by the large statistical effect of major events.

A major event day is a day in which the utility daily SAIDI (SAIDI/day) exceeds a pre-determined threshold SAIDI value. The SAIDI reliability index is used as the basis of the ME definition since it leads to consistent results regardless of utility size and because SAIDI is a good indicator of operational and design stress [3].

The daily SAIDI values are preferred to the daily SAIFI values because the SAIDI index is a better measure of the total cost of reliability (including utility repair costs and customer losses), than the SAIFI index. The total cost of unreliability would be a better measure of the size of a major event, but collection of this data is not practical.

The calculation of SAIDI per day for Eskom Distribution is a system challenge as there are six independent databases for each region, and a process challenge because 90% of all interruptions in a month have to be manually validated and audited.

The Eskom Distribution proposed that the definition of a major event is when "10% or more of all customers at a regional level only are affected by an abnormal event in a 24 hour period" [4]. The application of this ME process has to be transparent and auditable. This definition aligns with the commonly used major event criteria of electrical utilities in the USA.

Currently, in Eskom Distribution, the network reliability values include the major events.

Step restoration of supply

Step restoration is the process where the actions of the utility during interruption supply restoration mimics the actual customer minutes experienced by the customer. The customer minutes are accurately tracked as customers have their supply restored. It is assumed that the situation of "all the customers off and all the customer on at the same time" will be the worst case scenario for network reliability indices.

Depending on the step restoration methodology used by the utility the defined start and end time of an interruption can have a huge effect on the performance indices.

The following two definitions of an interruption duration are used internationally:

- The interruption starts when the customer calls to the customer call centre and the interruption ends when supply is restored by the field work staff.
- The interruption starts when there is a lock signal on the SCADA monitored substations and breakers. The end time is when the breaker is returned back to the supply signal, provided by the SCADA system.

In Eskom Distribution both of the above approaches can be used (including the paper operating logs) to ensure that the step restoration process accurately reflects what the customers experienced.

Data connectivity

Data connectivity refers to the complete and accurate number of customers connected to a transformer. In Eskom Distribution this is referred to as the customer network link (CNL). The process of connectivity refers to the ability of the system to infer the interruptions onto all the affected customers (even those customers who did not call in), from data related to the received calls or from the location of the affected device on the network.

When a transformer that serves 12 customers fails, but only two customers call in, does the system count 2 or 12 affected customers ? A utility with complete circuit connectivity takes the two calls, knows that the transformer serves 10 other customers and will record a loss of supply to all 12 customers. Utilities without circuit connectivity may only count the two calls as the total affected customers.

Without proper connectivity throughout the network and system, there is simply no way to know the exact number of customers that are out of supply for any given component failure nor to record the number accordingly. After implementing automated mapping systems with circuit connectivity and automated outage management systems (OMS), utilities have been known to experience increased reliability levels.

NER reliability requirements

The NRS 047-1 standard provides the minimum performance requirements of planned and forced interruptions of overhead and underground networks. The requirements shall be met with regard to at least 95 % of the customers.

In Eskom Distribution, more than 97% of the networks consist of overhead conductors. In effect the network reliability requirements of rural overhead lines (≤22 kV) are SAIFI ≤60 and SAIDI ≤200. The major concern about these indicative values are that they do not take into account the network length. There are no reliability levels defined for a customer on the end of a 300 km radial, rural line in South Africa.

The NRS 047-1 standard provides the following minimum customer restoration of supply times after a forced interruption :

- 30% of customers within 1,5 hours
- 60% of customers within 3,5 hours
- 90% of customers within 7,5 hours
- 98% of customers within 24 hours

Future regulatory reporting

The NER power quality advisory committee in 2003, recommended the use of the IEEE network reliability definitions and calculation methods for regulatory reporting in South Africa.

The interruption performance indices SAIDI, SAIFI, CAIDI and MAIFI (and in their planned and unplanned components), are part of the requirements of the future electricity distribution performance monitoring system (EDPMS) to be implemented by the NER.

The relevant information to be managed by the EDPMS includes financial performance statistics, safety statistics, environmental performance statistics, customer service performance statistics, technical performance statistics, and human resource statistics. This information will be used to support strategic goal setting and economic regulation [8].

The EPDMS will promote the use of incentive based regulation (IBR). Accurate network interruption data and information systems will be critical for successful implementation of EPDMS and effective IBR. The IBR will require accurate reporting methods and accurate data to also facilitate appropriate target setting.

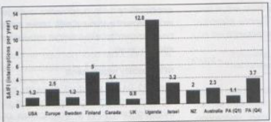

Fig. 2: International SAIFI comparison results.

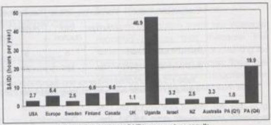

Fig. 3: International SAIDI comparison results.

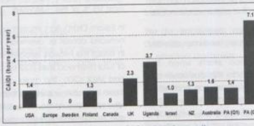

Fig. 4: International CAIDI comparison results.

For example, in the case of Norway, the data was accurate and based on over ten years of monitoring, whereas in the case of Italy more "arbitrary" targets were set based on only two years of data for some Italian distribution companies, no data was available at all.

The NER needs to ensure that there is uniform and consistent network reliability reporting of all the licensees in South Africa. The reality is that only providing a basic reliability index formula (such as SAIDI) will result in various different interpretations and various different approaches to which elements are included or excluded in the data. This may be a potential problem where licensees may be under pressure to seek "loop holes" that make their performance figures look better. This may require the compilation of a NRS 048 related standard to look at the MV network reliability measurement and reporting specification for all licensees in South Africa.

Future incentive based regulation

The network reliability (interruption performance) indices will be one of the inputs to the total productivity factor ("X") of the proposed incentive based regulation (IBR). The "X" factor is calculated to represent the level of efficiency that the NER requires the regulated entity to achieve. The IBR method has replaced the existing rate of return (ROR) method used internationally. The IBR methodology is based on the simple economic principle of "profit maximisation by cost minimisation".

The IBR is mathematically represented by the equation below [8] :

$$R2 = R1 \times (1 + RPI - X + Z \pm S)$$

where :

R2 is the new price and R1 is the current price

RPI is the regulatory price index which may be the consumer price index (CPI), the producer price index (PPI) or any other index which the NER may consider appropriate

X is the total productivity factor, which is calculated to represent the level of efficiency which the NER wants the regulated entity to achieve.

Z is a factor for exogenous costs that are outside the control of the utility management. These costs are subject to the NER approval on whether they qualify or not.

S is the reliability and quality of supply incentive/penalty

By approving an increase less than the RPI, the NER forces the utility to control their costs to also increase at a rate less than the index. The utility should therefore make sure that they achieve productivity equal to or greater than the "X" factor. This is achieved by the utility combining inputs that are possible at the least cost but which achieves maximum productivity. The IBR targets are for long term improvement so are normally over several years (for example three years in Europe).

Network reliability improvements were experienced in Italy when regulatory incentives were introduced. There was a 43% improvement in the average interruption duration and a 30% improvement of the average frequency of interruptions over three years [2].

International regulators have started to also consider momentary interruptions (MAIFI) and voltage dips as part of a holistic IBR application.

The challenge will be to find appropriate performance levels that are sustainable in the long term. Some of the short term based decisions by a utility, may result in the focus on the poor performing networks, but will not address the normal operation type maintenance and refurbishment requirements.

Country or Company	Information about the data used
USA	IEEE WG on system design 1997 survey quartile 2 results comprising of 61 utilities across the USA
Europe	The Council of European Energy Regulators (CEER) data for Italy and France based on 1999 survey results
Sweden	CEER results for Sweden based on 1999 survey results
Finland	Rural Performance. Acknowledgements KEMA Consulting, USA (IEEE/PES T&D Conference)
Canada	Integrated utility from Canada (1991-2000). Acknowledgements Dr. Ali A. Chowdry (IEEE/PES T&D Conference)
UK	CEER results for UK based on 1999 survey results
Uganda	Stone and Webster Management Consultants (Oct 2003)
New Zealand	Waitaki Area results of 2001 for 7 utilities
Israel	Israel Electric Corporation (IEC) 2000 to 2003.
Australia	Average of results for 2001-2002 of 26 Australian utilities
PA (Q4)	Values from PA Consulting data Quartile 4 over 3 years
PA (Q1)	Values from PA Consulting data Quartile 1 over 3 years

Table 2: Sources of data used.

Reliability benchmarking

International benchmarking

Various utilities from around the world participate in international network reliability benchmark programs. The standard benchmark programs look at three values of network reliability indices, 1) for all events included, 2) for events excluding the planned interruptions and 3) excluding major events, as defined by the relevant criteria established by the participating utilities [9].

The council of european energy regulators (CEER) established a working group (WG) on quality of electricity supply in January 2000. One of the main objectives of this WG was to perform a European benchmarking study on quality of service. This study included interruption performance and QOS data. The countries that participated in the study were : Italy, Netherlands, Norway, Portugal, Spain, France and the United Kingdom. Most of the countries had data available at a regional or district level [10].

Eskom Distribution has participated in the international PA consulting benchmark program (reliability certification program) since 2000, with utilities from Argentina, Australia, Chile, Brazil and Sweden. The intention of the program is to certify the reliability data capture, processing and reporting systems to align the metrics with international measures and best work practices.

A note of caution needs to be made about the difference between a direct performance comparison exercise and a true benchmark program. The difference needs to be clearly understood.

A direct performance comparison (number against number) does not portray the true picture and can provide very misleading results. Essentially one needs to compare apples with apples to ensure a more fair and representative benchmark exercise in order to gain any real value.

Figs 2, 3 and 4 provide a high level network performance comparison (the sources of data are indicated in Table 2). There is no underlying analysis of the measurement and reporting methodology used. The intention is to provide reflective network reliability levels of countries/companies around the world.

Influence of key factors

The following are key factors that influence and need to be taken into account, when conducting a network reliability benchmark exercise [9].

- Step restoration methodology
- Geographic area
- Lightning ground flash density
- Network exposure and design
- Degree of outage management system (OMS) automation
- Completeness and accuracy of data connectivity
- Degree of system automation (SCADA and distribution automation)
- Performance measurement methodology
- Cost of domestic electricity price

Similar key factors are discussed in [11] A performance normalization model is proposed for the distribution network operators (DNO) in the UK so that a fair and reflective performance comparison can be made amongst the DNO's.

Step restoration methodology

Discussed in detail in section 6.8. This might seem like a "basic concept" but the impact on the network reliability levels are significant.

Geographic area

The location of the networks, network distance from field service centers and the terrain (such as forests and mountains), have an impact on the reliability levels. Networks designed for rural areas are generally comprised of small substations with very long radial networks and with little network redundancy.

Systems in dense urban areas are normally made up of larger substations with multiple networks, redundant facilities, shorter line lengths and multiple interconnectivity.

Lightning ground flash density

The lightning parameter of importance for network lightning reliability is the lightning ground flash density. The ground flash density is the number of lightning strikes experienced per km^2 of ground per year. This is the measure of frequency of expected lightning strikes to an area or line. South Africa has a very high lightning ground flash density.

Network exposure and design

The percentage of the networks that are overhead compared to the percentage of the networks that are underground play an important part in the reliability levels.

It will be found that utilities with a large percentage of underground cables have better network reliability due to the low number of faults experienced on cable networks. On the rural networks, the basic insulation levels (BIL) of the woodpole structures is important. A rural network with 20km of exposure is inherently less reliable than an urban network of 5km.

Degree of OMS automation

For a fully connected model, the exact number of customers interrupted is known regardless of the system configuration. The most accurate OMS systems have fully integrated graphical information system (GIS) connected that provides network connectivity and customer counts.

The biggest impact is when a utility is in transition from a "legacy" system to a full OMS system. Legacy systems (paper and MS Excel) are typically systems capturing high level and sometimes inaccurate or incomplete data to assist with customer supply restoration. A full OMS system has complete and detailed data connectivity with fully integrated GIS and automatic tracing of events.

Completeness and accuracy of data connectivity

Data connectivity refers to complete and accurate number of customers connected to a transformer. The process of connectivity refers to the ability of the system to infer outages onto all affected customers (even those customers who did not notify the utility), from data related to the received calls or the location of the affected device on the network.

Degree of system automation

The degree of SCADA coverage and distribution automation (DA) used by a utility plays a important part in the automation of network fault identification, isolation and restoration. This usually improves the duration related reliability indices.

Performance measurement methodology

Many utilities have developed their own standards and eliminate such events as maintenance (planned) outages, customer caused interruptions, public caused interruptions and events over a certain duration.

Cost of domestic electricity price

The domestic electricity prices are a high level indication of the capital expenditure by a utility on the network. A high domestic electricity price indicates that the networks are built with redundancy and interconnectivity and should have better reliability levels.

Potential benchmarking of the NER

The end objective of a potential reliability benchmark program by the NER is, to cost effectively, improve the reliability of supply in South Africa. The benchmark can only be effectively done once there is a uniform and consistent reliability measurement and reporting of all licensees in South Africa.

The NER needs to compare apples with apples for accurate and reliable performance reporting and possible benchmarking between licensees in South Africa and potentially with international utilities.

This will assist in determining which best work practices the licensees should implement, to improve the reliability of supply to acceptable levels.

Value based engineering

A new trend with international utilities is the concept of value based reliability engineering. This is the optimal design of a network to reduce costs, but still to ensure adequate quality of supply and network reliability for the customer. The value based reliability planning methodology attempts to provide the minimum cost solution for the financial investments of utilities.

In a value based approach, there are no absolute values for the reliability indices (like SAIDI and SAIFI) that are applied to all networks in a utility. Rather the customer's reliability requirements, customer mix or industry; location of the network and design determine the acceptable reliability levels.

The customer is offered various reliability levels (depending on network design and construction etc) and the associated costs for each option. The network planning is becoming more "customer driven".

Lessons learnt

- There needs to be a combined focus on QOS and network reliability. Eskom Distribution is focusing on improving the "3Cs" (customer complaints, claims and contracts), maintaining the very good QOS levels and significantly improving the network reliability levels.
- Improvement in the network reliability levels requires strong management leadership, drive and support. Sufficient funding is required to be made available with the engineering management role-players engaging the financial management role-players for support.
- Network reliability is to be compacted at all levels in the business (different weightings or components) so that there is "ownership" for all staff. "Tighter" network reliability targets are unpopular especially if financial bonuses are linked, but critical if the network reliability levels are to be improved.
- The "small things" can also make a "big impact" on the reliability levels. Optimised field staff switching and fault finding and the correct step restoration practices require a culture change in the business.
- The international reliability benchmark results can result in a "distorted picture" and "apples may not be compared to apples". A closer investigation and understanding of the "finer workings" of other utilities is important. What network reliability levels are acceptable for South Africa ?
- The reliability measurement and reporting methodology needs to be uniform, consistent and most importantly correct. Only then can performance enhancement programs be effectively implemented on accurate and reliable data.
- Greater communication and customer awareness of realistic performance reliability is required. Some performance improvement projects (such as woodpole replacements) may actually deteriorate the reliability levels in the short term.
- Appropriate systems (partial OMS or a full OMS) and people awareness to support the business are required. A culture change towards "data excellence" is also required.
- Value based planning needs to be established to take into the customer expectations and requirements.

Conclusions

Network reliability will be a focus area of the NER and one of the key inputs to the IBR. It is critical that a standard network reliability measurement and reporting methodology is established for South Africa.

Network reliability levels appropriate for South Africa need to be established taking into account the inherent conditions (theft, high lightning density, long radial rural lines and low cost of electricity etc). There needs to be alignment with customer expectation and actual network reliability. Technically this may not always be possible and can lead to "unsatisfied" customers. Customer awareness and education is vital to prevent this.

There is an expectation that the network reliability levels will improve in the future REDs and the IBR application. It is important that reliability benchmark programs are used to support this performance improvement drive.

Acknowledgements

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The odyssey towards corporatisation - a roadmap for REDs ahead

by At van der Merwe, EDI Holdings

The document defines the journey toward corporatisation with the formation of Centlec (Pty) Ltd - the first municipal entity in SA, created in terms of the suite of new municipal legislation. With references to the formation of REDs Ahead it creates a roadmap for the creation of the regional electricity distributors in SA with emphasis on the requirements for the success of the new utilities from a finance, governance and institutional point of view.

The Mangaung's (MLM) electricity undertaking celebrated its centenary anniversary in 2002- the same year in which the council decided to undertake the necessary investigations in terms of the Systems Act [1] to prepare for REDs Ahead. At the time municipal legislation to guide the process was in a stage of development and the only guiding principles available came from the EDIRC process instituted by DME. The latter process however was in effect a continuation of the Pricewaterhouse Coopers (PWC) blueprint for the restructuring of the EDI in SA and could offer little assistance for the MLM journey to prepare for REDs ahead. Some schools of thought had it at the time that the effort by MLM was indeed one of creating something other than REDs – a selfish effort to safeguard MLM's own interest. This reason amongst others cautioned the local municipality to ensure that their efforts were clearly understood as an initiative to be proactive in support of the thrust of the PWC blueprint as accepted by Cabinet in 2001. It was thus of utmost importance to mark a successful process, that the value created should eventually enhance the service quality and commercial value of the undertaking upon entering into the RED.

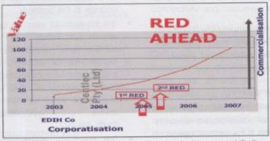

Fig 1. The increase of the expected business value due to commercialisation before entering into the RED.

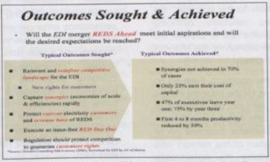

Fig 2: Typical outcomes sought from mergers and integration with outcomes achieved.

In order to understand the actions taken by MLM this paper will refer back to learning experiences of other utilities, research done elsewhere and international benchmarks applicable.

The Mangaung's rationale

MLM realised at a very early stage of the restructuring debate, that the vision for restructuring adopted by cabinet, implies that its electricity business will be transferred into the to be establish regional distributors. This necessitated a thorough understanding of the eventual compensation for its assets when part of the RED as per the PWC Blueprint, to replace the contribution to rates and taxes from the surpluses(profits) on the trading account. As per the constitutional mandate of local government to execute executive authority[2] over reticulation the governance role over electricity was yet to be defined. How would MLM in future administer this role?

In the many debates that followed over time, various other concerns and issues were identified to be important for municipalities. Amongst others, there were the stranded assets when the electricity business is eventually part of the REDS[3], MLM's ability to exercise revenue control, issues of cash flow and credit rating, internal economies of scale in service delivery in the municipality itself and others.

As the vision emerged through these debates, it became clear that it is of essence that Mangaung should prepare for REDS ahead by continuing with the restructuring of local government as a result of the Demarcation Act and the Municipal Structures Act, and, by organising the undertaking as a business entity to capture opportunities for greater efficiency and optimum service delivery.

This would:

- Ensure a clear business definition for the future revenue stream for Mangaung;
- It will provide experience in such governance and service delivery processes applicable in the future RED;
- Furthermore it will also demonstrate capacity and competency in delivery for institutional necessities such as an aspiring Metro;
- At the same time it will give leadership in the province time to optimise service delivery with regard to the governments' vision.

[1] Refer sections 76-78 of the Systems Act identifying triggers for a municipality and choices of internal and external investigation for service delivery.
[2] Municipalities have executive authority (S 156 of the Constitution)over electricity reticulation
[3] The PWC Blueprint stipulates that all businesses will be transferred into the REDs. This transfer is also defined in the draft EDI Restructuring Bill.

Fig 3. Summary of business processes to maximise shareholders value

How far does one need to go with the process of institutional change?

It has been said that if one does not know where you want to go, any road can lead you thereto. As part of the emerging vision it was understood by MLM that if the rationale for the process is to maximise the business value upon entering into the RED, commercialisation and the increase in business value can only be achieved over time after the corporatisation of the utility. Thus the more time available for this action, the greater the value to be achieved before the transfer of the electricity business[4] into the RED. This relationship is depicted in Fig. 1.

From the aforementioned the vision emerged that MLM could add value to its own business by preparing as soon as possible for REDs Ahead.

Mergers and integrations

Research has shown that only 40% of mergers and integrations are successful. It is not the purpose of this paper to analyse reasons for the successes and failures of such entities, but only to indicate the importance to seek the right outcomes and be aware of the risks in such processes. It is suggested that seeking the right outcomes and correct focus on these, increase the chances of real business success and service delivery for the electricity undertakings. In the Mangaung's investigations focus was placed on these international benchmarks and best practises as prerequisites for the setup of the entity. Several financial parameters and operational requirements were planned to enhance the shareholders value. For the EDI restructuring process in South Africa, the outcomes described in the following section can be identified as important for the merger between the distribution of municipalities and Eskom to be embarked upon.

Outcomes sought and achieved

Mergers and integrations of companies normally focus to achieve particular advantages for the participants. Unfortunately experience has indicated that the outcomes sought and those achieved, do not always correspondent. Generic necessities required for the EDI restructuring in South Africa (based on experience from other mergers and integrations) can be summarised as shown in Fig. 2.

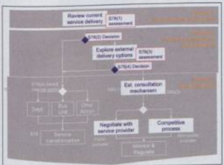

Fig. 4: The System Act's requirements.

Developing the way

From the above it can be concluded that it is of paramount importance to keep the rationale for the restructuring in mind as the process unfolds. For MLM (as it will be to a larger or lesser extent for the EDI restructuring) it was important to take clues from existing legislation, the White Paper and other business related benchmarks.

The vision, as adopted by government in the Energy White Paper, emerges as one of placing electricity supplies in a competitive market with choice and private sector participation. The PWC Blueprint[5] continues by defining this business nature further by giving more details to the expected business nature of the RED as an entity not only responsible for meeting customer expectations and future capital needs whilst serving its debt, but also for maintaining the right gearing levels to ensure sustainability and an adequate yield on investment.

In the competitive environment created by the Energy White Paper, government's intent is to level the playing fields, because governments normally find it difficult to be both player and referee in the industry. The eventual unbundling of the supply chain from generation to distribution will set the scene for competition and the expected efficiency and synergy gains in the industry at large. In the municipal environment in SA (the creation of City Power and Centlec (Pty) Ltd – both municipal entities in terms of the Systems Act) the corporatisation exercises preceded the commercialisation process and possible gains from it. In order to maximise shareholders value the parent municipality needs to allow these entities to change the conditions and structures under which the entity operates to enable these entities to achieve these benefits under market rules. Although ownership still remains with the original owners (with municipalities and the state, with Eskom as a custodian company) it is essential that management autonomy and accountability, as envisaged by the King Code, is allowed to reach these business goals. Fig. 3 depicts this journey in defining the thinking to be followed.

The Centlec story

The Systems Act's requirements (Fig. 4)

In the creation of Centlec (Pty) Ltd it was necessary to follow all the laid down requirements in terms of the Systems Act sections 78 -80. Three distinct processes can be identified, namely the initial assessment, further assessments and investigations and implementation. The process starts by reviewing the current service delivery [S78(1) assessment] to determine whether reason exist to explore external service delivery options [S78(3)]. Each phase is earmarked by definite decisions by the municipality to continue and to decide what kind of service delivery mechanism is preferred. During these investigations it became clear that an internal business unit cannot yield the expected business values necessary for REDS Ahead. MLM's investigations indicated

[4] The Blueprint describing in effect the transfer of net assets to the RED. An increased business value would theoretically increase the MLM's equity stake in the RED.
[5] See recommendation 19 of Blueprint for an comprehensive overview of the recommended business nature of the RED
[6] The interim board was meant for setup purposes and comprised of officials and councillors of the shareholder. As such it did not meet the full requirements of the Amendment Systems Act. However at the time the Amendment Systems Act was only a Bill and not promulgated as yet.

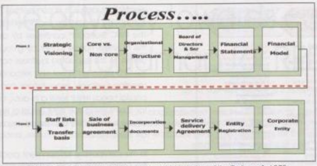

Fig. 5: The phase 2 and 3 process by MLM in terms of the Systems Act S78.

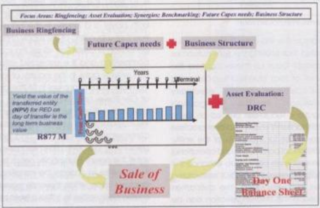

Fig. 6: The business evaluation process in creating Centlec.

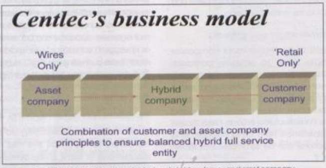

Fig. 7: The business model adopted - a hybrid customer and asset company.

that a municipal entity was the preferred option in MLM for service delivery.

The process followed

The process followed in the Centlec creation (Fig. 5) started with the strategic visioning for the entity (i.e where MLM needs to go to reach the rationale it has set for itself) and the identification of the core and non-core services and function rendered by the utility at that stage. With the core functions known, a new organisational structure was designed to meet the new needs. It was structured to facilitate a phased transition of staff from MLM to the new entity, whilst maintaining flexibility to allow for changes as the REDS process unfolds.

A shelf company Tamaron Trading was used to setup the company and later converted to Centlec. In the process, a new set of memorandum and articles of association was adopted by the company and registered with the registrar of companies. A process was followed to appoint an interim board[6] and followed up by a permanent board having the requisite expertise and skills as required by law.

However before the company was setup a full financial modelling was undertaken to determine financial viability and sustainability of the to be setup entity. This process is depicted in Fig 6. Prior to the sale of the business, the necessary service delivery agreements were compiled between MLM and the company, to ensure service delivery to the communities. The governance relationship that was created in the process is depicted in Fig 8.

The investigation undertaken

- Ringfencing of the business: All distribution assets, liabilities and staff were identified in relation to the electricity distribution supplies;
- Evaluation of all assets in terms of a depreciated replacements cost (DRC)
  - Assets of R1,14-billion were identified in an asset register and a process was embarked upon to compile a comprehensive asset register for accounting purposes;
- To understand the future requirements the business is going to face, a ten year demand forecast of electricity needs was done to define future capital needs of the entity;
- A comprehensive model was built to model the entity's financial viability and sustainability. The business value was modeled with a discounted cash flow (DCF) approach, valuating the entity conservatively with a NPV of R877-million
- Day one income and balance sheets for the new entity were compiled to reflect the status on day one of existence
- Business and company governance and operational structures were designed
- Legal issues for service contracts (service delivery and service level agreements) incorporation documents and company registration were outlined

The business model

The business is divided into wires and retail. As such the model that was adopted focused on both assets and customer

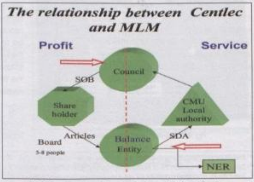

Fig 8: Governance relationship between MLM and Centlec

PatraX
Glands
SABS
S A
THREE-D
AGENCIES
Johannesburg: Tel: (011) 392-3804
Durban: Tel: (031) 305-8922
Cape Town: Tel: (021) 511-5654
Port Elizabeth: Tel: (041) 451-1741

Fig. 9: The change curve for people in accepting change.

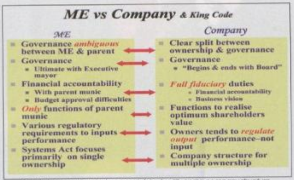

Fig 10: A comparison between municipal entity and a company structure

service. This structure necessitates contractual agreements with MLM for certain outsourcing of services such as the billing. It is foreseen that this arrangements will change as the entity grows more mature and as the EDI restructuring unfolds.

People's issues

It has been said that the human element is the reason why a proposal will not work or why mergers will be less successful or even fail. This very important nature was captured in the Centlec process with the identification and appointment of change agents to move staff through the elements of change as depicted in the change curve – Fig. 9.

Regular meetings were held with the staff to receive inputs and to pass through essential information. Although members of this forum did belong to specific unions and even shop stewards were part of this change forum, the forum did not deal with union matters at all, but focussed on the envisaged change and information sharing to the people itself.

Centlec: Features of the created entity

In a nutshell the characteristics of the entity created can be summarised as follows:

- The entity is a standalone electricity utility and a separate juristic person;
- As per definition in terms of the Municipal Systems and Financial Management Acts it is a municipal entity;
- It is a hybrid asset & customer management organization focusing on both components as foreseen in the EDI restructuring;
- The newly created entity has a service delivery agreement (SDA) with MLM;
- An entity focusing on electricity distribution business-functions of the parent municipality;
- The commercial arrangement is one of an interest-type payment to MLM as a shareholder with equity, defined as a nominal value only, structured for optimal tax and equity arrangements but also allowing the possible convergence from this shareholding into other equity arrangements and
- Is a commercially based electricity entity with GAAP compliant accounting

Governance

To create the new entity the business needs to be transferred to the newly created company as the new owner. In the MLM's case, this was done when the business was sold to the new municipal entity. This sale earmarked the transfer of the business. Between the new owner and MLM a service delivery agreement was put into place to discard the delivery role of the latter. MLM became the 100% owner of an entity operated by a board of directors, creating a balance between the profit motive and the service delivery need. Its role was transformed from a direct input into a municipal department to ownership through a shareholders agreement in a company. In a municipal entity's case governance ownership and effective control remains as constituted in the suite of municipal legislation.

Lessons learnt

At the completion of such a process several learning experiences can be identified. The most important ones are defined hereunder:

- Define the rationale for the change and the strategy clearly and upfront. Reconfirmation through the process is of critical importance to keep the process focused;
- Political buy-in for the process is of paramount importance and critical for success;
- Even in the most organized and well managed undertakings the processes takes longer than anticipated;
- Ringfencing of municipal electricity business is more complicated and involved than commonly believed;
- The capacity to execute processes in even the best running systems is often a problem- to keep the lights burning whilst transforming;
- Define detailed and measurable revenue enhancement and cost synergies clearly and upfront;
- It is really a paradigm shift from a municipal undertaking to a MBE;
- With the suite of municipal legislation there is plenty of appropriate legislation to be followed carefully and
- Appointment of key staff as soon as possible, to ensure continuity is important and thus a safety net for the leadership to take the process to its end.

What is problematic with the current arrangement as a municipal entity?

Introduction

To assess whether the current arrangement can yield the managerial accountability and autonomy to achieve a system in which the business synergies and efficiencies can be captured to increase the value of the entity, one needs to analyse whether the new dispensation leaves the entity more flexible and streamlined than in the previous arrangement within a municipality. Because the increase in shareholders value will only be achieved over time and such organisations have an inertia of its own from a service delivery point of view, it will be rather difficult to appreciate whether the arrangements is one of creating an environment to achieve optimum business performance upfront. What arrangements will yield optimum performance? What constitutes business success? One needs to measure such arrangements against criteria laid down by current legislation, stipulations and recommendations of guidelines such as the King Code and others. This envisaged future is unpacked in definitions and requirements for the to be formed REDS.

Features of the RED

Many features of the REDs can be identified. For the purpose of this paper to understand the business nature required by the REDS in order to capture synergies, efficiencies and to operate in a streamline fashion, the following amongst others can be identified:

- A new juristic person separate from existing owners i.e. municipalities and Eskom or the State
- There should be a clear split between

ownership and fiduciary duties in directing the company in support of the rationale of existence as laid down in the memorandum and articles of association of the RED, i.e. clear distinction between existence of the company and interest of its owners

- The purpose to maximise its shareholders value and in the South African context of service delivery, have both monetary and service excellence dimensions
- To capture the strengths of all participants by having an equilibrium in ownership
- Long term financial sustainability of the electricity entity

The municipal entity versus the company

King Code 2 defines clear governance and ownership relations in the known company structure. The accountability as one of that begins and ends with the board. It compared with the governance arrangements in terms of the suite of municipal legislation the accountability ends in the parent municipality, requiring a whole host of regulatory requirements and controls as far as finances and budget is concern. The necessity of strict financial regulatory controls is acknowledged, when the structure acts in public interest as custodian of communities. Whether such a structure can create the necessary environment to achieve the required outcomes sought, as earlier alluded to in this paper, is questionable. Experience in the created municipal entities in South Africa indicates that governance between the parent and the entity is problematic. Further development in this regard will be of essence if this structure is to be used in the REDs.

Closure

Clear value was added in the in the establishment of Centlec (Pty) Ltd . The rationale for the change, as set upfront was achieved in creating the entity in its preparations for REDs Ahead. By this much greater understanding was created and above all the business value was identified for MLM's future equity stake in the RED. From this point of view it can be said that MLM was successful in its endeavour.

However to maximise the shareholders value upon moving into the RED and the maintenance of the current surplus or profit levels can only be achieved, if the to be achieved synergies and efficiencies can be unlocked through a process of commercialisation. This will largely be dependent on whether a true paradigm shift by the shareholder form a municipal utility to a business enterprise will be made and whether the entity will be allowed to setup structures and systems to achieve this. For this full management autonomy and accountability is needed as recommended in the King Code 2.

It appears that the suite of new municipal legislation does not easily allow for such a paradigm shift and it is suggested that some institutional problems that do exist that will hamper these necessary relationships for optimal business performance. As such it is early days to tell whether real long-term customers benefit will be achieved in the current municipal entity structure under the current legislation. It is suggested that the definition as a municipal entity as the preferred structure for the RED appears to be problematic and will not yield the envisaged results as envisaged in the different restructuring documentation and research.

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Key industrial customers – what are the options?

by Corrie Visagie, Eskom

The position of key industrial customers, also referred to as potentially contestable customers, in the restructuring of the EDI has not yet been clarified by the policy makers. The first RED is planned for middle 2005 and this issue needs urgent attention.

Key industrial customers form the engine of the South African economy and use large amounts of energy. In some cases their electricity consumption makes up more than 30% of their operating cost. As far back as 1996, key industrial customers expressed their opinion, as part of an NER Large customer task team, stating that they want choice of supplier in the electricity industry. In the industry many opinions exist about this topic, but unfortunately not enough time is devoted to this subject in the various restructuring debates.

The first part of this paper explores the various alternatives available to decision makers in the EDI restructuring phase before the introduction of a multi-market model or full ESI restructuring and analyses the advantages and disadvantages for the major players such as the South African Government, REDs, Eskom, EDI Holdings and key industrial customers.

Key customer definition

The definition of a key industrial customer which later changed to the term contestable customer was approved by the NER to include the following criteria:

- Annual electricity consumption of ≥100 GWh
- On a single contiguous site
- Under a common management structure

This definition was incidentally also later accepted as the definition of a qualifying WEPS customer and is also currently applied to individual municipalities. There will of course be additional market rule requirements from the NER for potential wholesale participants as discussed in the second part of the paper.

Key customer needs

The needs of the key industrial market segment were expressed in the report of the NERs large customer task team in 1996 and again in a position paper published by the Energy Intensive Users Group. In summary, these are:

- Internationally competitive and cost-reflective pricing of electricity,
- Appropriate quality and reliability of supply,
- The ability to negotiate mutually beneficial contracts with their electricity supplier, and
- The right to choose their electricity supplier.

They also recognised the need to contribute to electrification and rural levies, but would be unhappy to contribute to municipal taxes on top of it. The preference is rather to be taxed on profits.

Key customer options

When one considers the various options that could be considered in deciding how to deal with key industrial customers during the restructuring of the EDI, five possibilities come to mind. These are:

a) All customers are allocated to the REDs
b) Key industrial customers are allocated to Eskom and the rest of the (captive) customers are allocated to the REDs [A variation of this option could be that both Eskom and the Munics/REDs retain their existing key industrial customers.]
c) Key industrial customers are offered (limited) choice between Eskom and the REDs
d) Full retail contestability is introduced to the key industrial segment
e) Contestability is phased in to a wider customer base but restricted to the industrial segment.

To promote understanding of the paper, the following basic structure is recommended:

- An introductory section, clearly setting out the background to the paper
- Main body of the paper
- A conclusion summarising the findings of the paper
- References, appendices and acknowledgement of sources and persons who co-operated in the compilation of the paper

When one considers the merits of these options, the assumption is made that contestability or customer choice could be introduced without introducing generation competition at the same time. The energy rates will therefore be regulated as part of the WEPS methodology.

Evaluation criteria

Any option needs to be tested and the following factors have been identified as possible evaluation criteria

- Political acceptance by all players
- Skills availability
- South African economic impact
- Customer acceptance
- Impact on RED viability
- Impact on market liberalisatio

Analysis of options

The analysis of the options become very complex as each of the options needs to be viewed from the major stakeholders point of view, these being key industrial customers, REDs, Eskom and the Government.

Political acceptance by all players

There is a perception that unless the REDs have the full geographical customer base within its supply area, it will not be able to levy electricity for cross-subsidisation purposes. This is further exacerbated by the picture of total revenue contribution to the total ESI. This issue is further discussed below. I believe a better understanding of the revenue flows in the industry will assist in making a more informed decision.

Skills availability

Over the last few years, Eskom has identified critical skills required for the industry and has embarked on extensive training and development programmes, specifically in the specialist areas of electricity pricing, energy trading and forecasting. The complex capability for trading has been built up in the Eskom regions and is still in the process of further development. However when one considers the specialist nature required to deal with contestable customers, there are not enough skills to go around in six REDs. That is why Eskom has centralised the critical skills required to service this complex customer market. The type of complexities that arise are related to issues of special agreements such as commodity-linked and foreign currency agreements and related risk management and hedging mechanisms as well as mechanisms to motivate customer participation in dynamic short term products. In the absence of an electricity market, these products are developed in close co-operation with the System Operator and Eskom Generation to facilitate customer participation.

SA Economic Impact

Electricity has provided South Africa with a real competitive edge over the past decade and has enabled large energy-intensive industries located in South Africa to compete effectively in the international market. A number of key industrial customers have special pricing agreements with Eskom that enhances customer competitiveness. There are also some customers with a national focus that prefer dealing with a national supplier for consistency and predictability. However, one of the major considerations in attracting investment to South Africa, is the role of a central marketing arm working closely with the Department of Trade and Industry and the Industrial Development Corporation. When a company considers South Africa as a potential location for investment, it would not know from the outset in which geographic area to set up. The negotiation process to conclude an acceptable electricity supply agreement is generally very complex because of the unique requirements of this type of investor. There are several countries in the world able to provide a favourable environment to energy intensive users. The establishment of a single retailer with the ability to service the key industrial market is a vital strategy to maintain South Africa's competitiveness against other countries in attracting energy-intensive users. The industry needs a national focus to promote South Africa – not several regional entities competing with each other and also competing against other countries.

When the national environment encourages the attraction of new energy-intensive investments, then every industry and individual in South Africa will benefit from associated economic growth.

Customer acceptance

As key industrial customers have repeatedly stated their preference for customer choice, it seems obvious that their preference would be any one of options C, D or E.

Impact on RED viability

The fact that the revenue from key industrial customers comprises 40% of Eskom's revenue, has led to a perception that REDs will not be viable if they do not have this revenue as part of their direct customer base. However, the retail margin for this market segment is around 2 to 3%. This is due to a large portion of the revenue being returned to the REDs in return for the use of distribution wires, as well as the payment of electrification and rural levies. The short answer therefore is that the financial impact of not having access to the revenue generated by key industrial customers is really 2 to 3% of 40% resulting in an impact of approximately 1% of the total revenue of the industry. This amount is not going to affect the viability of a RED materially.

However, the major factor that is often overlooked in discussions on this subject is the issue of commodity and currency risk exposure in this market. The possible annual swing in revenue from aluminium agreements alone can easily wipe out the margin referred to in the previous paragraph. It is also doubtful if a newly formed RED would be able to offset this risk with a financial institution due to the stringent balance sheet requirements from financial institutions.

Internationally, generators have recognised the need for agreements with retailers to reduce their risk in investments in generation capacity. Retailers in turn need access to generation capacity to meet their commitments to customers. The integration of generation and retail is an important development to reduce risk - and reduced risk means reduced cost for consumers.

Impact on market liberalisation

The Energy White Paper calls for the introduction of competition into the South African electricity market and this issue has also been favoured by government over the past few years. However, international incidents and experiences seem to have influenced a reluctance to move too fast with the ESI restructuring. It nevertheless still seems as if a market, or at least a limited market system, will be introduced at some time in the future. It is therefore important to have the necessary mechanisms developed timeously. Examples of such mechanisms are the development of the wholesale electricity pricing system (WEPS), appropriate wheeling charges and the like. Clearly the options allowing customer choice will be a step towards a competitive market, whilst retaining the monopoly relationship with customers as suggested in options A and B, will not be moving forward.

This is especially true if the REDs are going to set up as bundled retail and wires entities. When one considers option B on the other hand, Eskom has created a special division to focus on this particular customer segment. By setting up this division, Eskom has identified many issues in terms of the unbundling of the various relationships and agreements between the various internal components that make up Eskom and the industry. Examples of this are the relationship with the wires owners, energy procurement, and ancillary services.

Conclusion

The high level analysis done in this paper confirms that we are dealing with a complex issue, but in the end, the right decision should be one that is in the broader interest of customers and of course the South African economy. The main purpose of this paper was to ensure that the members of the AMEU receive a wider understanding of the issues surrounding the key industrial customer market, with the view of addressing certain incorrect perceptions.

If one then considers the various options put forward in this paper, it certainly appears that option C, that is 'limited customer choice', offers the best solution for the industry at this point in time.

Alternatively, option B could be considered if a simpler solution is sought before the introduction of complex mechanisms such as contestability. In this scenario, it would probably be advisable that both Eskom and the municipalities retain their existing customers going into the REDs.

References

[1] NER large customer task team Report, 1996

[2] EIUG position paper on electricity supply industry restructuring , 1999

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Experiences during a financial ringfencing assignment

by Ken King, Merz and McLellan

The objectives of this project were to determine the value of the assets, liabilities, revenues and costs of the electricity undertaking, to prepare a GAAP/GAMAP compliant ongoing set of accounts and to extract and share the learning experience, so as to improve the effectiveness and reduce the costs of similar future projects in other municipalities.

The MIIU, who provided the funding for the project, laid significant emphasis on the learning experience and this is the primary subject matter of this paper. The compliant set of accounts include income statement, balance sheet, cash-flow statements and management reports.

The paper covers the experiences of the assignment and offers some insights to the process. The municipality under study (which is described in broad terms below) is not really relevant to the paper as it is typical of many smaller authorities in the country.

Merz and McLellan have played an ongoing role in the restructuring process but were not part of the original Pricewaterhouse Coopers (PWC) assignment for the Department of Minerals and Energy (DME), and have not been party to all the recent discussions and deliberations. This was regarded as a setback to start with, but a fresh set of eyes has provided a changed insight to the challenges and opportunities that present themselves. The same answers will not be provided for the second time. Also worth noting is the fact that when the assignment was undertaken, the ringfencing tool kit was not in existence in the public domain and it has therefore not influenced this work.

Background to the EDI Restructuring

The background to ringfencing is well known and there is little point in dwelling on that aspect but some brief comments are useful. The white paper on the energy policy of the Republic of South Africa, drafted by the Department of Minerals and Energy, acknowledges serious structural problems in South Africa's distribution industry which lead to challenges such as:

- Difficult access to affordable electrical energy for a large part of the population;
- Difficulties in the governance of electricity undertakings which had heretofore been structured as municipal services rather than best practice utilities which yielded differential tariffs and service levels amongst local authorities on the one hand and Eskom on the other;
- Many municipalities are not always in the best financial health
- Attraction and retention of competent employees is difficult in many areas.
- Rationalisation of the tariff systems is desirable.
- Lack of investment for the refurbishment and maintenance of the networks is an on-going challenge.

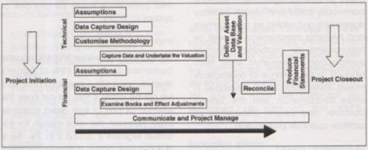


Fig. 1: Project approach

The white paper proposes and commits government to the restructuring of the industry to achieve a combination of increased competitiveness and focused regulation to ensure a self-sustaining industry ultimately servicing the benefits of all of the electricity customers. The department subsequently crafted the blueprint (Electricity Distribution Industry Blueprint Report February 2001) to provide further direction on how restructuring will occur. It is in response to this blueprint that the ringfencing assignments are being undertaken.

The restructuring of the electricity distribution industry is probably the largest such endeavor carried out in the country and the risk to all the stakeholders is immense. The EDI has expressed concern that the restructuring process must be carried out in a well-structured and orderly manner and that there should be no big bang. The EDI project office has produced a framework for the process and the DME, Eskom and the municipalities (represented by The South African Local Government Association (SALGA)) have committed to the process through the acceptance of the co-operative agreement provided that all the contentious issues are dealt with appropriately. The time for implementation was originally set for the first RED to be established during June 2004 but the process has been fraught with difficulties and only two municipal undertakings have been ringfenced to date. Eskom Distribution has been active in converting their distribution networks from seven to the required six regions so that there will be a minimum number of distribution plants crossing RED boundaries which will facilitate the integration of the networks and systems.

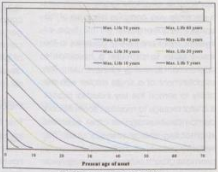
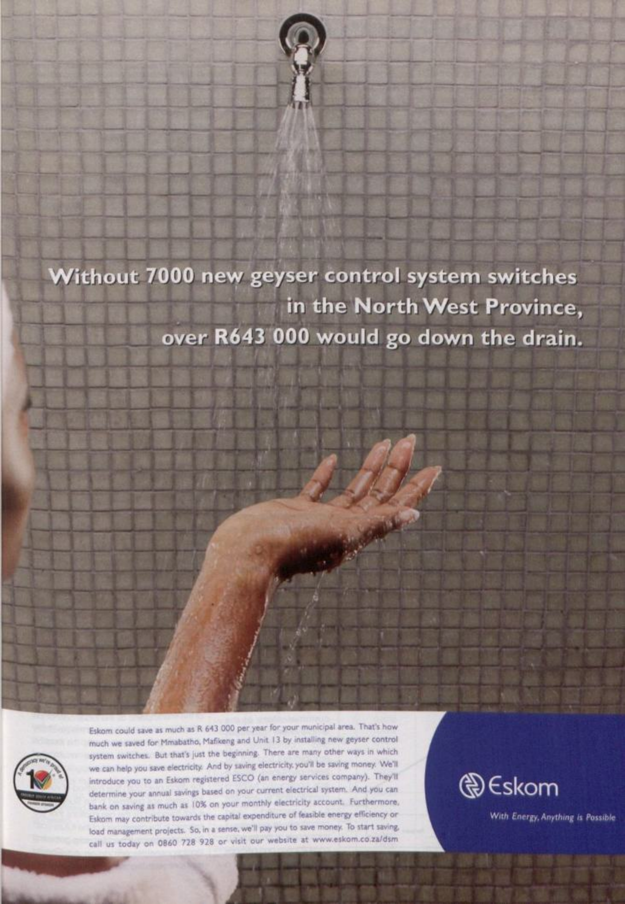


Fig. 2: Remnant lives of assets.


Without 7000 new geyser control system switches
in the North West Province,
over R643 000 would go down the drain.
Eskom could save as much as R 643 000 per year for your municipal area. That's how much we saved for Mmabatho, Mafikeng and Unit 13 by installing new geyser control system switches. But that's just the beginning. There are many other ways in which we can help you save electricity. And by saving electricity, you'll be saving money. We'll introduce you to an Eskom registered ESCO (an energy services company). They'll determine your annual savings based on your current electrical system. And you can bank on saving as much as 10% on your monthly electricity account. Furthermore, Eskom may contribute towards the capital expenditure of feasible energy efficiency or load management projects. So, in a sense, we'll pay you to save money. To start saving, call us today on 0860 728 928 or visit our website at www.eskom.co.za/dsm
A democracy we're proud of
Eskom
With Energy, Anything is Possible

addressed later in the section covering the assumptions made for the assignment. The arithmetic applied in the methodology is relatively sensitive to the life assigned to the assets.

Having established the present day replacement cost and the remnant life the present day replacement cost is calculated using the straight-line depreciation principles. Provision is also made for the residual value of the asset elements when they are retired.

Valuation Assumptions

The most important assumption to be made is the remnant life of the asset.

Other jurisdictions, notably Australia, New Zealand and Singapore, have established statuary or regulatory lives which have developed over time with more and more agreement between the parties as experience improves. This simplifies the provisions for depreciation on a straight-line basis to large extent. It is interesting to note however that these lives vary between jurisdictions to a considerable extent.

Table 2 provides a selection of the regulatory lives in Australia at the present time.

The other jurisdictions indicate a much shorter life with Singapore averaging 20 years and New Zealand somewhere between the two. In the absence of a regulatory life for assets in South Africa we have adopted the methodology based on the principles of life expectancy, which follows those related to the expectation of human life, which is commonly used by the insurance industry which has been described earlier. On that basis, the adjustment for depreciation depends on the probable residual life of the asset and not a prescribed duration as adopted in Australia and New Zealand. We have adjusted the maximum possible lives, using engineering judgment and experience of the lives of similar equipment to take account of the condition of the equipment observed in the field and recorded by the municipal staff members engaged in the data gathering for the assignment.

Results

Table 3 shows a summary of the results of the valuation and demonstrates the asset classification applied. Overhead lines are 11 and 22 kV, all 380 V lines and aerial bundled conductor lines have been included as part of the "consumer"category, which has allowed for all the assets from the low voltage bushings on the transformer. A point to note is that the data collected referred to aerial bundled conductor medium voltage lines as open wire type and system studies are based on those parameters so we have adopted the same rationale in the asset register as it is consistent with our functionality approach. The non-core assets of the streetlights and other social services are excluded from the valuation of the electricity assets.

The "other assets" classification includes plant and vehicles, tools and inventories.

Financial statements

The development of a set of financial statements proved to be quite challenging. The assumption cannot be made that the municipality's current set of accounts are without audit endorsement and accurately reflect the financial state of the authority. Support from financial staff soon waned once the scale of the problem became apparent. Much of the required data was not available or in a condition to generate the statements without a fair degree of assumption interpolation and estimation. The identification of investments fully associated with the Electricity Department could not be achieved with confidence. Note should be taken that most of the investments of the municipality were only possible because of the revenue generated by the sale of electrical energy. It was however possible to show that the electricity department had sufficient investments to cover their reserves.

Long term debtors included a number of staff loans which varied from individual to individual and were governed by separate HR policies of the constituent municipalities. Incorrect PAYE deductions resulted in the staff being granted loans to cover large amounts owing to the SARS.

The inventory control policies were very loose resulting in all inventory being recorded in the books at zero value.

The debtors age analysis reflected inordinate amounts owing to the municipality for longer that 90 days. It is assumed that a large portion of this will never be recovered and the apportionment of the loss so sustained will no doubt still be a cause for contention.

The bank and cash accounts could not be adequately reconciled, whilst the VAT input and outputs had not been raised for months.

The issues mentioned above are but a sample of the problems encountered and the purpose of reporting this is simply to make the statement that the preparation of the financial statements for the municipality's electricity department was not a simple desk study in this instance.

Returning to the asset valuation once more the asset value recorded in the municipality's books of account based on a historical cost basis, was approximately 16% of the depreciated replacement cost, indicating the difference between these two methods.

Key learning points and recommendations for future financial ringfencing assignments

The assignment was started with a significant level of uncertainty in regard to the full scope of work required of the consultants. More time should be spent on ensuring that the terms of reference are clear and unambiguous. The requirements of this specific assignment are somewhat unique as the requirements for the "pilot" elements were not fully appreciated.

The success of an assignment depends in large measure on the co-operation and attitude of the staff and officials of the client. They need to be advised of the importance of the work and that the results are of value to their employer. The auditor general endorsed the financial statements of the municipality and the figures used in the assignment are compromised.

One unexpected occurence was the fact that the municipalities, which were amalgamated to form the municipality, had not completed their integration process and many business practices, assets and liabilities were not common. This covered a number of matters including staff rules regulations and practices and insurance and other financial issues. These could lead to serious consequences in the future.

As the assignment progressed it became clear that the financial and operational ringfencing should have been undertaken simultaneously in order to execute the work more efficiently.

Many of the principles to be applied to the separation of the electricity undertakings from the municipalities and their subsequent integration into the REDs still form the subject of debate. Clarity is needed so that the practitioners can be properly briefed and that the debates do not occur whilst the consultants are attempting to finalise the work.

The resources can be most efficiently deployed if the assignments are undertaken in a continuous establishment and not on a stop start basis.

EDI Holdings Company is in the process of developing a "ringfencing toolkit". The methodology and detail of the work is not yet in the public domain and it remains difficult to comment on the efficacy of such an initiative. Given the complexity of the data and systems encountered in the municipality and the state of the financial statements in general, we would recommend that the toolkit is not overly prescriptive and mechanistic as a fair amount of professional judgment and skill has had to be brought to bear on the assignment.

The purpose of the ringfencing and valuation needs to be confirmed as there is some doubt that the methodologies adopted will not be regarded as a sound basis for the transfer of the assets and for the payment (in cash or otherwise) to a local authority for forfeiting the right to generate revenue from their electricity undertakings.

The interest of the National Electricity Regulator has not been given much attention in this assignment and due care should be adopted in future to insure that all the role-player valuation requirements are properly addressed.

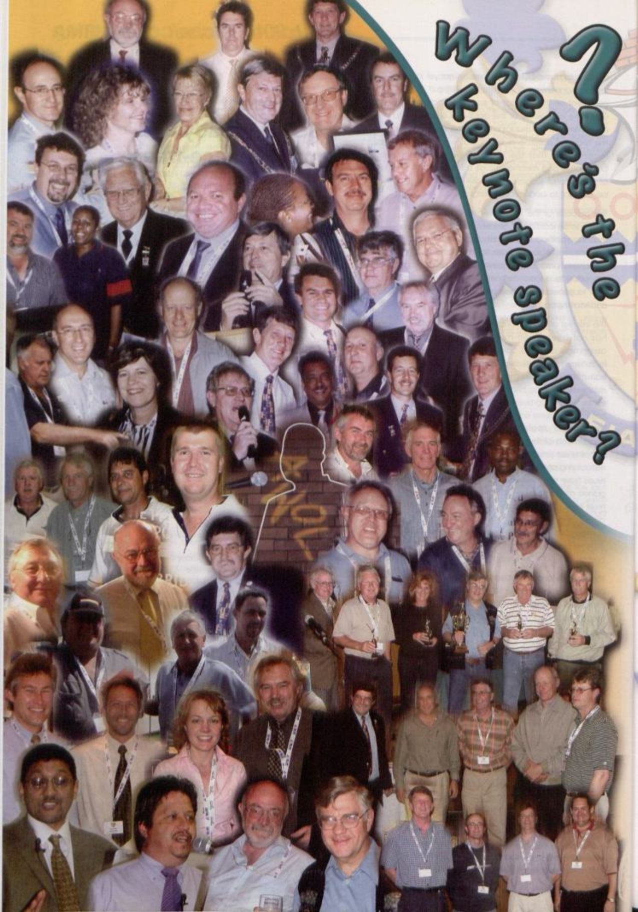
Conclusion

The task of ringfencing all the electricity departments of the municipalities in the country remains an enormous and vital task for the restructuring of the industry. All of the contentious issues have not been ironed out and experience gained on assignments such as the one described must be fed back into the system. There is little doubt that some of the valuations and compensations allowed in the establishment of the REDs will be adversarial and there is no identifiable best practice of note internationally for guidance.

The experiences described are but a selection of those actually encountered and have been presented as such. The formation of the REDs will require additional ongoing studies in relation to the responses to the condition of the plant, maintenance costs, system development and cash flow requirements and tariff rationalisation.

In conclusion reference is made to an assignment undertaken by Merz and McLellan for the AMEU, which was prepared to identify the "optimum number of financially viable REDs for the EDI in South Africa". The economist who undertook the work made it clear that viability depended on the tariff policy and level, and the result is unlikely to emerge from continued analyses of the figures in the system. The electricity networks were established by the municipalities in South Africa for the provision of services to their residents, businesses and rate payers. Tariffs were set for associated reasons including the subsidisation of the rates bill and the attraction of people to the municipality. I trust that we bear this in mind as we attempt to massage the industry into best practice utilities using business principles alone. Δ

? Where's the keynote speaker?



who's who at the CEMA

The managed contract as an alternative to streetlight maintenance

by N. Crossley, and C. Parfitt, PMCE

The conventional approach to streetlight maintenance has historically been council controlled, however in recent years this approach has begun to change with specific councils utilising electrical contractors on a direct contracting basis. This we believe is fraught with danger, particularly if there is not a dedicated administrative structure in place to manage these contractors. The following paper seeks to outline an alternative option, based on a proven 'cost effective' managed contract approach, which can provide an acceptable service and at the same time deliver on covernments desired requirements of 'job creation'.

What is the secret of sound maintenance procedures? To put it simply 'good management'! Of course that is a bit too simplistic, however there is no real alternative to achieving the desired result for large maintenance projects, than the constant control of a dedicated management team.

We at Project Managers-Cunsulting Engineers (PMCE) believe very firmly that there is real value in the 'managed contract route' as an alternative to the direct contract approach whereby council administers the systems in-house.

The system outlined below was developed jointly between senior engineering staff at Benoni CCC (Ekurhuleni Metro) and PMCE, (formally Niewalt (JHB) Inc). This managed-contract approach has evolved to encompass the needs of council for:

- Realistic service delivery
- Demands for safe and sound engineering control
- The ever present requirement for cost effective delivery.

The figures and statistics provided were compiled by Ekurhuleni Engineering Staff using comparisons between different divisions of the Metro and an article outlining the overall success and benefits achieved from this managed contract approach, was published back in 2002.

We believe that the direct contract approach can lead to:

- High demands on council internal management
- Manipulation by contractors
- No dedicated streetlight management structure
- Substandard workmanship
- Substandard materials

Historical figures complied by Ekurhuleni Merto, indicate that this 'direct contracting route' has almost always resulted in increased maintenance costs, as reflected below.

With the managed contract route the demands on council are greatly reduced. Control can, if required, pass over in total to the project manager, thus transferring responsibility for all aspects of service delivery including, contracting staff performance, materials supply and ultimately quality control.

PMCE currently control some 50 000 streetlight units on behalf of Benoni & Germiston Customer Care Centres, as 'management consultants' and have been engaged in this process for the past six years.

To achieve the level of service delivery, project control and management skill that PMCE are currently able to provide for projects of this nature, has taken many years to accomplish. It must however be stressed, that this process was not developed in isolation, but rather by listening and incorporating the requirements and improvements which senior municipal staff sought to implement.

The system presently in operation has delivered by dramatically reducing on all of the following:

- material usage;
- complaints received; and
- overall maintenance costs.

These improvements have been acknowledged as a positive element for the metro both by engineers and councillors alike.

Role of project manager

The role of the project manager includes:

- Preparation of detailed contract documents sufficient to cover all aspects of construction and maintenance work on a daily basis.
- Preparation of specifications for materials along with the total control of same.
- Detailed 'financial administration'. A critical element in any successful process.
- Implementation of 'after dark surveys',
- Collation of fault and survey reports,
- Issue of 'daily works orders',
- Supervision and control of completed work and
- The monitoring of contractors performance along with the preparation of monthly reports.

Scope of work

The scope of work, should by right, include the maintenance of all public, street and area lighting including, the repair of lamps, fittings, poles and cable faults.

Results achieved

The following figures provide a simple analysis of the results achieved by comparing three different approaches to streetlight maintenance within three different divisions of the same Metro. The results speak for themselves and can be verified by Ekurhuleni staff as required.

The system however remains sufficiently flexible to allow for any specific requirements, or changes needed, to comply with an individual metro/ council's wishes.

To summarise the results achieved:

- The system availability in Benoni reached a high of 99% and continues at these levels
- The material usage dropped during the first year by 40%
- The complaints reported by the public dropped by a staggering 75%
- The recorded costs during financial year 2001/02 reflected figures as low as 50% below that of other regions.

There is simply no good reason why service delivery on streetlight maintenance should cost substantially more within one municipal area compared to another.

Software

PMCE have developed an extremely comprehensive software package (S/L Man 02) specifically for the control and implementation of streetlight maintenance. This programme is capable of providing a broad spectrum of information including actual network details, cost analysis of every fault, dates when works orders were both issued and completed, materials utilised, contractor

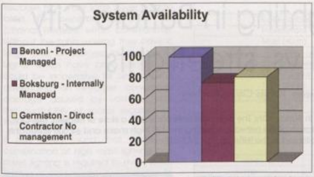


Fig. 1: Comparison of system availability using three different approaches to streetlight maintenance.

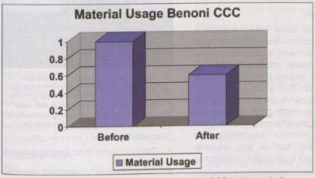


Fig. 2: Comparison of the materials used n Benoni CCC before and after implementation of new approach.

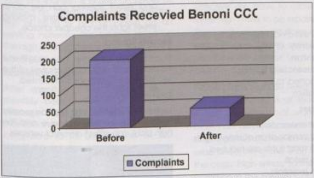


Fig. 3: Comparison of the number of compaints received before and after "managed contract" in use.

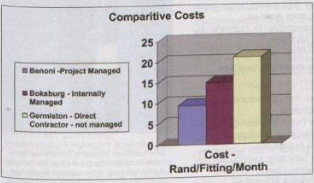


Fig. 4: Comparison of costs using three different approaches, measured in Rands per fitting per month.

implementing repairs etc. The extent of information provided is invaluable and far surpasses that available to any other municipality or metro in South Africa, today.

The information resulting from the application of this programme provides sufficient detailed statistics, to enable the controlling structure to consider alternatives with regard to the need to rationalise methods and materials utilised on any network. This rationalisation has successfully been applied to lamps, fittings and poles.

Critical success aspects

During the past five or six years certain elements of the work implemented by PMCE on streetlight maintenance have stood out as being critical to the success of our management approach. These can best be defined as:

- "After dark" surveys on a regular cycle, (every two weeks)
- Quality control of materials supplied.
- Constant availability of materials.
- Dating of all replacement items for follow-up purposes.
- Use of SMME contractors and confirmed job creation measures.
- Contractors only paid for work successfully completed.
- Strict control of works orders - no duplication.
- Inspection of completed work.
- Reconciliation of all materials used.

Job creation

This management process has proved to be extremely effective in the arena of job creation. The evidence of this can be substantiated by the Benoni experience whereby an increase of almost 400% in people employed was achieved.

SMME development

Although streetlight maintenance is not very demanding technically and is therefore ideally suited for emerging SMME contractors, there are still certain engineering requirements to be adhered too prior to commencement of work. PMCE provide (free of charge) continual training for all appointed contractors, in conjunction with an accredited engineering structure, to ensure adequate technical skills are utilised continually.

Guaranteed price structure

PMCEs extensive experience over a number of years, provides the unique ability to offer a guaranteed fixed price sum for whichever approach a specific council/ metro may wish to consider. This offer can be fully inclusive of materials, construction and management.

Conclusion

With a number of municipalities currently considering an alternative approach to streetlight maintenance, along with other non-core functions, particularly in light of the impending restructuring of the supply authorities and establishment of the REDs, the system of a managed contract has, we believe, real merit and is worth particular consideration.

References

[1] Specific information and values disclosed within this paper have been provided with the approval and kind permission of Ekurhuleni Metropolitan Municipality.

[2] A DVD copy of the full presentation delivered at the recent AMEU 20th Special Convention in Richards Bay is available to all interested parties. Please contact the authors. Δ

An analysis of lighting in Buffalo City - high mast vs. streetlights

by Robert S. Ferrier, Buffalo City Municipality

In 1997 the Township of Mdantsane was incorporated in Buffalo City. The electrical network was in a state of neglect. The City awarded a R63-million two-year contract for the rehabilitation of the network including the 120 high masts and ±4 000 streetlights. The lighting was rehabilitated to the tune of about R3-million.

After the rehabilitation, the expenditure to maintain the whole of the electrical network was monitored. Consequently it was found that 75% of the lighting budget was being spent on the 120 high mast lights. After further investigations, the following were examined.

- Installation cost
- Maintenance cost
- Energy consumption cost
- Municipality's responsibility
- Other factors affecting lighting

Why provide lighting?

When analyzing the lighting policy the first question that needed to be answered was "why does the municipality provide lighting"? Some of the reasons are listed below:

- Road safety and better traffic flow
- Helps deter crime and vandalism
- Improves the general appearance of residential areas
- Improves general living standards
- Provides security

What do our consumers in low-income areas want?

While it is not the municipality's responsibility to provide security lighting, this is the main requirement in low income areas.

The municipality needs to balance this requirement with its responsibility to provide street lighting and in so doing ensure customer satisfaction. If this can be done, then communities will take ownership of the street lighting thus reducing vandalism.

Parts of the community want to retain high mast lighting because they provide security lighting. Adequate security lighting can be provided with the use of street front lighting - if street front lighting is correctly designed and uses a luminaire fit for this purpose. To ensure that the consumer accepts this new type of lighting, they need to be educated. Pilot projects can also be used to show consumers what to expect.

The type of lighting used is dependant on the nature of the terrain and the income level of the residents. In a high income area where most homes have their own security lighting, but traffic is higher, mainly road lighting is required. In lower income areas where there are fewer cars and the consumers do not have security lighting, a combination is required.

Light pollution

Environmental issues have become a major concern worldwide, and light pollution has been spotlighted. Some countries have already adopted legislation to reduce light emissions, yet is was decided that South Africa would follow with its own legislation. The type of lights used on high mast systems are designed to provide security and sports field lighting. As these types of fittings are not shrouded, light is lost upwards causing the sky to glow (light pollution).

A close investigation into high mast and streetlights showed the following:

High masts

Advantages

- To the uninitiated, high mast lighting is apparently cheaper to operate and maintain.
- It provides security lighting.
- It is purported to be less susceptible to vandalism.

Disadvantages

- Costly when vandalized.
- Usually a combination of streets lights and high mast lights are required.
- Costly to install.
- Costly to maintain.
- Hazardous to motorists due to the glare.
- When not functioning, large areas are left in total darkness.
- Highly susceptible to damage by lightning and birds.
- Light pollution.

Conventional streetlights/post tops

Advantages

- Enhances the appearance of the residential area.
- Cheaper than high mast lighting (on existing electrical installation).
- Conforms to SABS 098 - 1.
- Post top luminaries provide security lighting without being obtrusive.
- Easy to install and maintain.
- Residents take ownership of their lights.

Fig. 1: Cost of repairing the damage, because of vandalism, to this high mast light was R40 000. All the luminaries, trailing cable, steel cable and the control panel were stolen. The lighting platform and door all had to be replaced due to the damage.

Disadvantages

- Costly to install if no existing network is available.
- Conventional streetlights provide very little security lighting to houses.
- If planned correctly electrification and street lighting can be done simultaneously, therefore making street lights the cheaper choice.

Security lighting

Since security lighting is a big issue in low income areas, a detailed analysis of the security lighting options is presented.

High mast lights

High masts when working provide security lighting, but are very obtrusive and the high glare can affect drivers of vehicles.

Fig. 2: Shown in the picture is a local resident who has been trained to install streetlights. Some municipalities have taken this training further and use local residents to change light bulbs thus creating work opportunities. But all electrical connections remain completed by electricians.

Because high mast lights cover a large area, they became targets for the criminal element within communities. Without the lights working they have a large area of darkness to operate in. Lights, which have been vandalised, could be inoperative for several days depending on weather conditions, damage caused by vandals, and the availability of spares required for the repairs.

It has been found that usually a combination of high mast lighting and street lighting is required to meet street lighting standards. This can be due to land contours or large buildings causing shadowed areas.

Streetlights (post tops)

Streetlights provide very good security lighting without being obtrusive and provide street front lighting, that meets the require-ments of the SABS street lighting standards.

It has been found that the consumer, for whom the light provides security, takes responsibility for it and imme-diately reports any fault to the municipality. This ownership reduces vandalism too.

Installation costs

(This cost is based on installing the lighting on an existing reticulation network).

Cost comparison is based on prices as quoted on 10 May 2004 for the installa-tion of 55,70 W HPS luminaries on an existing network. The lighting head on the high mast is fitted with six 1000 W HPS floodlights.

Maintenance costs

After monitoring the budget on a monthly basis it was found that on average R25 000 is spent on the maintenance of the 120 high mast lights compared to R5 000 for the ±4 000 streetlights on materials alone.

Table 2 shows a comparison of typical faults, which occur, in the street lighting network.

As can be seen from the table, the labour for the repairs to the high mast lighting is very high. This is due to the fact that the lighting platform needs to be lowered for work to be carried out.

As this task falls under the Occupation Health and Safety Act (lifting gear), it requires a competent person to be available on site at all times.

Typically it takes 25 minutes to both lower and raise the platform on the mast (i.e. a total of 50 minutes).

For lamp replacement on a high mast to be cost effective you need to have at least three lamps out. This of course reduces the effectiveness of the mast in the interim.

	High mast	Conventional/post top
Supply cable	R2000	On existing
Foundations	R17100	N/A
Mast (40 m)	R52000	N/A
Crane	R11600	N/A
Labour to erect mast (no electrical work)	R6500	N/A
Control panel	R6000	R2500
Light fittings	R25000	R71500
Lighting cable	R1800	R1200
TOTAL	R122000	R75200

Table 1.

Task	High mast		Post top	
	Materials	Labour	Materials	Labour
Cable	R720,00	R400	R16,00	R35
Lamp	R490,34	R200	R114,70	R50
Ballast	R780,90	R350	R180,35	R200
Complete luminaire	R2 197,27	R350	R950,00	R100

Table 2: Comparison of typical fault costs for high mast and post top lights.

There is a substantial increase in costs when a fault occurs to the steel trailing cable/lighting platform, which requires the hiring of a 30 ton crane.

Such faults, which occur, can be attributed to:

- Bird nests on the lighting platform.
- Jamming of the platform lowering mechanism.
- Vandalism.
- Lightning strikes that cause damage to trailing cables.

For the use of a mobile crane to be cost effective you have to allow for at least three high masts to be repaired at a time. This cannot always be done, as each high mast provides lighting over a large area and therefore cannot be inope-rative for an extended period of time.

As the crane must be hired for a full day the cost incurred is at least R8 000. It should be noted that work on a high mast can only be carried out on calm days (light wind). Any delays caused by wind once the crane is on site increase the costs. High winds, to this extent, are common in the Eastern Cape.

Energy consumption costs

The comparison below is based on an area covered by a 40 m high mast. It has been established that you would require between 50 and 60 (70 W) HPS light fittings to cover the same area using conventional street lights. We have based our calculations on 55 fittings.

High mast

6 x 1000 W = 6000 W

Taking an average of 10 hours working per day the cost of running a high mast per year would be:

6 kW x 10 h x 365 days x R0,26/kWh = R5 694 per annum

Conventional street lights/post tops

55 x 70 W = 3 850 W

Taking an average of 10 hours working per day the cost of running the conventional street lights would be:

3,85 kW x 10 h x 365 days x R0,26/kWh = R3 653,65 per annum.

The annual energy cost for high mast lighting is R2 040 higher than that of the equivalent street lighting.

There are 120 high mast installations in Mdantsane which cost R244 842 per annum more to run than the equivalent number of conventional street lighting luminaries.

Conclusion

High mast lighting is more expensive to install and maintain.

Security lighting can be provided without having to resort to high mast lighting.

Because conventional streetlights are situated closer to consumers they take ownership, thus reducing vandalism.

Light pollution can be reduced by installing the correct type of lighting for the job on hand. (i.e. use post top fittings to provide security as this type of fitting reduces upward light, and therefore reduces sky glow but still provides adequate lighting without being obtrusive).

After considering the above the Buffalo City Municipality have taken the following decisions:

- To remove all high mast lighting installations as and when they fail.
- To install only conventional streetlights.

This of course does not mean that high mast lights do not have a place, but they should be used primarily be for security lighting of factories and for sportfield lighting. Δ

How can technology reduce the cost of street lighting?

by Johann Schleritzko, Beka

Street lighting has gone through a number of technological advances which offers significant advantages for the operators of these installations. This paper debates these technologies and summarises their economical impact for the operators.

Improved lighting technologies offer reduced capital costs as well as reduced energy and maintenance costs. Many local authorities, however, who are the custodians of public lighting, are not yet embracing the opportunities these technologies offer and are therefore missing the opportunities that an efficient street lighting installation offers.

The available technologies:

Significant improvements in technologies have emerged in the field of:

- Reflector designs
- Luminaire designs
- Lamp technologies
- Circuit control technologies or telemanagement

These technologies provide the public lighting engineer with opportunities to operate more efficient public lighting systems. Since the public lighting is the visual manifestation of the local authorities' commitment to the wise spending of public funds, the public lighting engineers are well advised to apply these cost advantages, offered by these techniques, to the benefit of their councils.

Reflector designs within the luminaire

Since the reflector is the heart of the luminaire, it ultimately determines the efficiency of the installation. Modern reflector designs increase efficiencies up to 80%, therefore increasing the spacing or lighting levels.

The design of the reflector and the luminaire will determine:

- Whether the physical consistency of the reflector allows distortions under heat or deformations over time
- How well this reflector is protected from long-term dust and humidity ingress, as determined by the IP rating of the lamp compartment. This is covered by the SABS document ARP 035, which recommends IP ratings of a minimum of IP 65 and for coastal areas IP 66.
- The lifetime of its electrical components, as a result of their exposure to dust and dirt. Again, ARP 035 recommends IP ratings of the gear compartment to be not less than IP 65.
- How it survives the mechanical pounding on the pole structure, as caused by passing vehicles, amplified by means of whiplash action to the luminaire body and its components. Therefore aluminium housings for group A type luminaires are required in terms of ARP 035. This also acts as a safety precaution against heavy luminaire components, such as ballasts, becoming detached in cases of accidents.

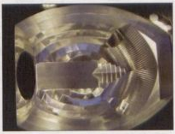


Fig. 1.

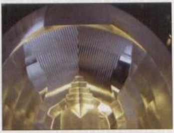


Fig. 2.

Fig. 1 and 2: Modern reflector designs increasing efficiency up to 80%.

The lamp

The new generation of high pressure sodium has advanced to an average of 132 Lm/W.

It has also increased its lifetime to last in excess of four years in public lighting installations.

Circuit controls

Available technology enables the reduction of the luminous flux of the lamp, with similar reductions in the electrical power used.

Typically, a 400 W high pressure sodium lamp, if reduced to 45% of its lumen output, reduces its power consumption by 46%. This would enable the operators of the road lighting to reduce the lighting levels at a given time, or at a recorded traffic flow, and hence reduce the energy costs.

This technology shall be considered, particularly for all class A road installations of 250 W and higher.

		Conventional	BEKASTRADA-Supra, with SUPER lamp and POWER SWITCH
Lamp lumen	lm	48,000	55,500
Cost per lighting hardware, inclusive pole and luminaire	R	6,878	9,460
Spacing	m	54	76
No of lighting units		18.5	13.1
Total Capital Cost	R	127,240	123,934
Total lamp replacement costs	R	2,839	897
Total energy costs	R	22,503	11,933
Total annual operating costs	R	25,342	12,830

Table 1: Combined benefits for an A2, median arrangement, per km.

		Conventional	BEKASTRADA-Supra, with SUPER lamp and POWER SWITCH
Lamp lumen	lm	48,000	55,500
Cost per lighting hardware, inclusive pole and luminaire	R	10,806	13,407
Spacing	m	54	76
No of lighting units		18.5	13.1
Total Capital Cost	R	199,913	175,640
Total lamp replacement costs	R	2,839	897
Total energy costs	R	22,503	11,933
Total annual operating costs	R	25,342	12,830

Table 2: Combined benefits for an A2, opposite arrangement, per km.

The effect of the capital and energy cost

Reduced capital and energy costs result in the following:

- Increased pole spacing reduces the number of poles and luminaires required per length of road, resulting in lower capital and energy costs.
- Fewer luminaires require less maintenance
- Fewer poles represent fewer obstacles on the road, hence reduced likelihood of damage.

Policy decisions

Following from the above, it is recommend that local authorities take cognisance of these technologies in their public lighting policies, reviewing the following aspects:

- The differentiation between luminaires for new projects, where pole-spacing can be determined, and maintenance, where the benefits of reflector technologies are not necessarily resulting in cost savings.
- Luminaire procurement policies for new projects, by applying "scheme-price" tendering. The use of the most cost-effective luminaire can be established by means of a public procurement process, which is establishing not the lowest cost per luminaire, but the lowest "scheme price".
- Change lamp standards policy to only procure long-life lamps and high-output lamps, as available from all major brands,
- Power-switch technologies for all new group A1, A2 and A3 installation.

Applicable standards

It has to be noted that since 1 August 2004, the Standard SANS 60598-2-3, has become a compulsory specification. This obliges every street light manufacturer to have their luminaires tested to this international safety standard, which prescribes a rather detailed set of tests. Part of this test procedure is the testing of the IP rating of the lamp and where applicable, the gear compartment. The result of this test shall be recorded on the label of the luminaire.

Conclusion

New lighting technologies available in South Africa, offer substantial advantages particularly for new road lighting installations. Policy and decision makers are encouraged to embrace these technologies for the short and long-term benefit of the operators of these installations. Δ

A standard for medium-voltage cable systems in Eskom Distribution

by Greg Whyte, Eskom Distribution Technology, and Rhett Kelly, Eskom Distribution Central Region

This paper deals with some of the design philosophies that are unique to the Eskom Distribution Standard for medium voltage cable systems i.e. SCSASABL6: general information and requirements for medium voltage cable systems (1). The intention of this paper is not to address every design requirement for a medium-voltage (MV) cable standard but rather to focus on those that are often overlooked.

Over the years the Eskom Distribution business has consisted of a number of regions, the boundaries of which were determined by the provincial boundaries of the country at the time. In the past twenty years the business has been through a complete cycle of decentralisation and then since 1990 - centralisation. In the late 1980s the regions were autonomous with regards to business practices. The result of this was the creation of standards and specifications by each region that were suitable to the specific requirements of that region. Purchasing of equipment was also handled on a regional level. Although there were technical special interest groups that met to share experiences and ideas there was no drive to have a common national distribution standard.

In 1990 Eskom Distribution committed to the government driven "Electricity for all" project and all regions were contributing to meet the target of 300 000 customer connections per year. It was soon very clear that there was a need for a national standard for low cost electrification projects and that economy of scale could be achieved by having a centralised purchasing system. The "Electrification Standard" was created with input from all regions and soon after national contracts were established with various suppliers for the purchase of strategic equipment. The DTAB (Distribution Technology Advisory Board) was established which was a corporate body with regional representation that was responsible for managing the Electrification Standard and implementing it. By 1993 the Electrification Standard had grown to a document that covered more than just low cost electrification practices and included substations, urban reticulation, street lighting, survey etc. A clear omission from the Electrification Standard was any form of standards for high-voltage, medium voltage and low voltage underground cable systems. This was not seen to be a problem at the time as Eskom Distribution was predominantly seen as an overhead lines company. Furthermore the Eskom regions that were doing underground distribution had suitable regional standards in place albeit differing significantly.

In 1997 the DTAB was changed to the TESCOD (Technology Steering Committee for Distribution). TESCOD was tasked with developing a technology business plan for Distribution that would assist in achieving the overall Eskom objective of providing the lowest cost electricity. TESCOD saw national standardisation of business practices as one method of reducing cost in the business and became the driver of this philosophy. Political changes in the country resulted in Eskom regions that were not previously involved in under-ground distribution taking over areas with extensive cable networks. In 1997 the decision was made that national standards should be put in place for LV, MV and HV cable systems. Presently there are numerous published national standards and specifications relating to cable systems. This paper covers some of the design philosophies that are unique to the Eskom Distribution standard and relevant specifications for medium voltage cable systems i.e. SCSASABL6: general information and requirements for medium voltage cable systems.

A medium voltage cable standard

Fundamental requirements

General

Advances in MV cable and accessory technology over the last 20 years has resulted in certain common practices that Eskom believed to be inappropriate for use with locally manufactured MV equipment (e.g. compact switchgear). The equipment has not kept up with the respective technology trends making it difficult to apply a systems approach. For example, the type of cable, the equipment and the type of termination used to connect the two have become incompatible.

One of Eskom's primary objectives in compiling a standard was to look at the entire MV cable system and address the incompatibility issues that were identified - resulting in a 'system' that is comprised of components that are type tested for application together. Specifically, the following key aspects were taken into consideration:

- interfacing of MV cables with compact switchgear (i.e. for connections rated ≤ 630 A);
- interfacing of MV cables with metal-clad switchgear (i.e. for connections rated ≥ 800 A);
- impregnated paper-insulated (PILC) versus XLPE-insulated cable with reference to the compatibility of accessories at 11 kV and 22 kV;
- belted versus individually screened cable designs with reference to the SABS 0200 (2) earthing philosophy adopted by Eskom; and
- the transition from cable boxes designed to be compound filled to properly designed air-filled cable boxes used with dry type terminations.

Electrical requirements

The majority of South African supply authorities only have to consider the requirements for secondary distribution networks rated at 11 kV. Eskom, however, has to include the requirements for reticulation at both 11 kV and 22 kV due to:

- substantial amounts of existing 22 kV underground cable networks; and
- the fact that the majority of MV overhead reticulation is done at 22 kV and often provides the source for an underground cable network.

Eskom's earthing philosophy for MV reticulation is in accordance with SABS 0200 effectively implying that the earth fault levels are limited by the use of resistive neutral point earthing. As a result cable and accessory specifications are designed accordingly.

Mechanical requirements

The mechanical requirements for an MV cable system effectively, encompass ensuring a compatible cable - equipment interface. The interface must provide adequate space for the termination of the cables required to meet the current rating while maintaining the electrical clearances. The rating of equipment in Eskom has been standardised as shown in Table 1.

Equipment description	Current rating (A)
Compact switchgear and auxiliary equipment (e.g. transformers etc.)	≤ 630
Metal-clad switchgear	800
	1250
	2500

Table 1: Standard current rating of equipment.

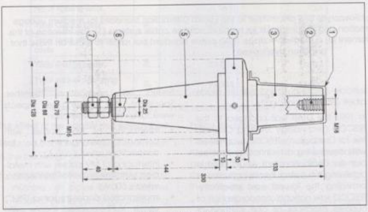


Fig. 1: 630 A type C bushing.

In the past, a number of failures of air-insulated metal-clad switchgear have been attributed to the switchgear supplier failing to provide a suitable cable-equipment interface. The problems have been identified as one or more of the following:

- manufacturers striving to make the switchgear as compact as possible to reduce cost and space requirements;
- switchgear designs that are based upon international practices e.g. for the termination of single-core MV cables that are relatively flexible with small overall diameters in comparison to SABS specification cable;
- the South African practice of using three-core armoured cables requiring significantly more space for terminating; and
- inadequate provision made for the termination of multiple cables per phase in order to match the respective current ratings of the switchgear panels.

Equipment rated ≤ 630 A has traditionally been supplied with various non-standard customised bushings onto which the MV cable had to be terminated. An example of this is the numerous types of bushings supplied with compact switchgear (e.g. oil-filled ring main units). This has resulted in the cable jointer having to be sufficiently skilled to cope with the various types of termination-bushing interfaces. This is believed to be an unrealistic expectation in an industry where no formal accreditation of cable jointers exists. In order to address this Eskom sought to adopt an internationally recognised and widely accepted bushing interface i.e. the EN 50181 (3) standard 630 A M16 x 2 type C bushing. The bushing dimensions are shown in Fig. 1.

In addition to the non-standard bushing interface the position of the bushings relative to the incoming cable has in the past resulted in a number of problems during cable termination. This is particularly the case where large cables are terminated e.g. 185 mm².

Traditionally switchgear suppliers have provided brass wiping glands suitable for the termination of lead sheathed cables. The wiping gland provided both mechanical support and a means to connect the cable sheath to earth. With the advent of solderless earth connections (e.g. constant force springs) in modern termination kits, wiping glands are no longer required. As a result, often no cable support was provided with the equipment resulting in significant mechanical loading on the terminals or bushings. Another common problem is where the cable support provided is too close to the bushings to allow the cable to be terminated correctly.

The numerous problems experienced by Eskom with the cable equipment interface highlighted the need to clearly define the respective types of cable terminations that could be used and the associated mechanical and electrical clearances required. In order to address this, Eskom initiated the compilation of NRS 012, cable terminations and live conductors within air-insulated enclosures (insulation co-ordination) for rated a.c. voltages of 7,2 kV and up to and including 36 kV (4).

Environmental requirements

Air-insulated enclosures that house terminations or live conductors are not hermetically sealed and are subjected to contamination from dust and other air borne pollutants. Unlike in outdoor applications, insulation associated with equipment inside air filled enclosures does not have the benefit of natural washing from rain. Condensation in air filled enclosures is very difficult to prevent, and when it combines with

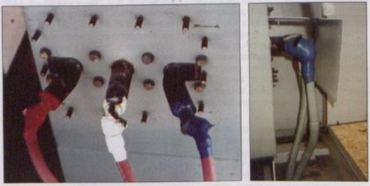


Fig. 2: Oil-filled RMU bushing arrangement, front and side view.

Fig. 3: SF6 RMU bushing arrangement.

Fig. 4: Unsupported MV cables terminated into switchgear.

Fig. 5: Differing specific creepages applied in switchgear.

Fig. 6: Tracking on the surface (i.e. < 10 mm/kV) of a CT used in switchgear.

pollution can lead to tracking and, in severe cases, flashover. The Eskom experience with "indoor" air-insulated enclosures in the past was that suppliers did not apply a consistent design philosophy with regards to creepage. This is illustrated in Fig. 5. In certain cases, insulation with specific creepages of < 10 mm/kV were found. The build-up of pollution on insulation in air filled enclosures is generally slow and failure due to insufficient creepage will occur long after the guarantee for the equipment has expired.

NRS 012 specifies a minimum specific creepage of 20 mm/kV for insulation supporting live bare conductors in air-insulated enclosures. Eskom requires that insulation complies with the requirements of NRS 012 to reduce the probability of a pollution related flashovers and to minimise the maintenance requirement for these enclosures.

Insulation co-ordination

Selection of impulse insulation level

SABS 1019 (5) has been adopted by Eskom for the selection of impulse insulation levels. Two impulse insulation levels are defined by SABS namely for exposed (i.e. overhead lines) and non-exposed (i.e. cable networks) installations. In Eskom, reticulation networks are often a combination of cable and overhead lines. As a result, where possible, the higher insulation level has been specified. The reality however, is that for 22 kV systems, commercially available equipment is generally not available for the higher insulation level (i.e. 150 kV). As a result attention is drawn in the Eskom standard to the application of surge arresters at 22 kV on cable connected equipment connected to overhead lines.

Minimum clearances in air-insulated enclosures

Laboratory condition type testing of equipment does not guarantee that the installation in the field will meet the required insulation levels. Eskom's experience in this regard has been that the site installation often varies significantly from the type tested arrangement. This has particularly been the case in the areas of panel assembly and MV cable connections.

With these problems in mind NRS 012 was compiled to establish design guidelines and uniform requirements for insulation co-ordination within air-insulated enclosures. Although NRS 012 focuses on cable terminations within air-insulated enclosures, it is applicable to any live conductors within air-insulated enclosures, for example metal-clad and metal-enclosed switchgear.

The NRS 012 clearances between live bare metal, phase-to-phase and between live bare metal (one phase) and earthed metal are in accordance with the recommendations of IEC 60071-1 and IEC 60071-2 (6) for the applicable lightning impulse withstand voltage, and are based on dielectric strength considerations of the air gap.

Prior to the publication of NRS 012, the manufacturers of MV equipment paid very little attention to the minimum required clearances to be maintained between shrouded (insulated but unscreened) live metal components. Examples where this has occurred are as follows:

- unscreened single core cables connecting the compact switchgear (e.g. ring main unit) to the transformer in mini-subs that are close to or in contact with earthed metal; and
- unscreened single-core cables connecting the voltage transformers to the busbars in metal-clad switchgear that are close to or in contact with opposing phase busbars or earth.

Due to the nature of the insulation the mistakes made in the above scenarios will not be highlighted by a short-time overvoltage test performed as a type or routine test. Instead the failure may take a number of years to occur, i.e. long after the guarantee for the equipment has expired. NRS 012 now provides the minimum requirements to be complied with to ensure long term performance of the equipment. Clearances between shrouded live metal, phase-to-phase and between shrouded live metal (i.e. one phase) and earthed metal are in accordance with the recommendations of Cenelec HD 428.2.2 S1 (7) for the applicable rated voltage. The clearances are based upon dielectric strength considerations for lightning impulse and AC withstand voltage (i.e. corona inception and extinction) of the air gap and solid dielectric combination.

Having stated all of the above Eskom was faced with a problem on imported compact SF6 gas insulated switchgear. The cable box dimensions on the switchgear are accepted internationally

Fig. 7: Insufficient live bare metal clearance to earth.

Fig. 8: Unscreened VT cables in switchgear busbar chamber.

Rating (A)	Cable size
800	2 x 185 mm² 3-core
1250	2 x 630 mm² 1-core/phase
2500	4 x 630 mm² 1-core/phase

Table 2 - Cable size for metal clad switchgear rating

and cannot be influenced by the relatively small local market. Eskom therefore had to ensure that suitable methods of cable termination were applied. These are as follows:

- at 22 kV, screened separable connectors (SSCs) are used. This was the primary reason behind Eskom's decision to standardise on XLPE insulated cable and SSCs for reticulation at 22 kV; and
- at 11 kV, indoor terminations with unscreened separable connectors (USCs) are used. This option allows for the use of either XLPE or PILC cable. Although the clearances in the cable box are below those required by NRS 012 the risk is minimised by ensuring that the terminations and USCs are type tested in accordance with IEC 60055-1, IEC 60502-4 and equivalent CENELEC specifications at the reduced clearances provided in the cable boxes of this switchgear.

The publication of NRS 012 has not guaranteed implementation by the manufacturers and Eskom has had to continually ensure that the requirements of NRS 012 are consistently applied from the design stage to the final installation on site.

Primary plant equipment

The following section deals with the specific technical interventions that have been made by Eskom in order to address the requirements and problems highlighted in the previous section.

Metal-clad switchgear

The traditional practice of the manufacturer supplying and installing switchgear panels is no longer common in Eskom Distribution. As a result, it is necessary to ensure that the switchgear is as "user-friendly" to the contractor installing the equipment as possible. It is critical that the 'number of on site "surprises" are minimised as the contractor cannot be expected to make decisions on site that may affect the insulation co-ordination of the panels.

The metal clad switchgear used by Eskom is designed to always accommodate the following arrangement of cables relating to the rating of the panel:

For each cable terminated into the panel a separate flag is provided for each lug to be connected (i.e. no back to back lug connections are accepted). This is to ensure that the live bare metal can be properly shrouded to meet the minimum clearances required by NRS 012. This philosophy is applied irrespective of whether the switchgear is designed for live bare metal or shrouded clearances for the following reasons:

- the cable jointer always applies the same type of termination; and
- to reduce the risk of the lug, bolt and nut connection compromising the required clearances. An example of where this has occurred on site is shown in Fig. 9.

Fig. 10 illustrates a panel where the philosophy of a separate tag and support is provided for each incoming cable. Each panel is also supplied with a vermin proofing plate that is pre-drilled and fitted with tapered rubber grommets that are cut on site to suit the cable diameter.

An 800 A panel is often connected by means of a length of cable to an overhead line. In the event that additional surge arresters are required to be installed in the panel, it is necessary to ensure that this can be done in a way that the clearances required by NRS 012 are met. The compactness of certain designs of switchgear prohibits the use of conventional outdoor surge arresters and necessitates the use of fully shrouded indoor arresters. This is illustrated in Fig. 11 and 12.

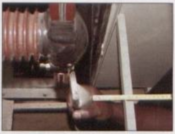


Fig. 9: Inadequate clearance due to installation of lug on 2500 A panel.

Cable

The debate regarding the benefits of XLPE insulated cable versus impregnated paper insulated cable (PILC) continues and will not be discussed in this paper.

The Eskom standard caters for both types of cable and the application of either is based upon:

- installations in "Greenfield" areas versus extensions to existing networks; and
- the type of equipment, system voltage and related accessories that are to be used i.e. the fact that SSC's cannot be used with PILC cables is often overlooked by the users.

The London Metals Exchange price of copper and aluminium dictates the type of conductor that is most cost effective at any particular time. Eskom however has standardised on copper conductors for the following reasons:

- to minimise the stockholding requirements to cater for both types of cable (i.e. lugs, ferrules, cable etc.);
- the core and outer diameters of a copper conductor cable are smaller for equivalent ampacity than an aluminium conductor cable facilitating easier working when jointing and terminating;
- conductor jointing using compression methods are simple for copper conductors whereas there are numerous differing opinions regarding the crimping requirements for aluminium cables; and

Fig. 10: Provision for each incoming cable on 2500 A panels.

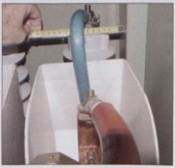


Fig. 11: Outdoor surge arresters fitted with insufficient clearances.

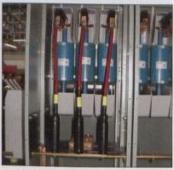


Fig. 12: Indoor surge arresters fitted with sufficient clearances.

- to avoid the bimetallic corrosion problems associated with termination and jointing of aluminium cables (i.e. brass or copper terminals on equipment).

The problems with water treeing in XLPE insulated cables are well documented. Eskom has adopted the recommendation made by SABS 1339 (8) to use a polyethylene outer sheath on all MV XLPE cable as it is more robust and impervious to water than PVC. A drawback with PE is its flammability and therefore in applications where the cable is exposed above ground level (e.g. when terminating to an overhead line), special precautions needs to be taken. In these cases a protective steel pipe is used.

The lead sheath or armour of the cable is used as the earth continuity conductor (ECC) of the cable feeder. In order for the cable to perform this function, the rating of the earth circuit must be greater than 2 kA for 3 seconds. Using the lead sheath or armouring as the ECC implies that a separate counterpoise earth is not required to be installed with the cable.

Cable accessories

Prior to 1998 the supply of cable accessories (i.e. cable joints and terminations) to Eskom was not regulated. Although some Eskom regions partnered with suppliers that provided type tested products, the lack of control allowed opportunist suppliers to supply inadequate and untested accessories. In 1998 the Eskom and NRS 053 (9) specifications for MV cable accessories were published. In both cases the type test requirements were based upon IEC 60055-1 (10), IEC 60502-4 (11) and equivalent CENELEC specifications. Since 1999 Eskom has committed to purchasing only cable accessories that are type tested accordingly. This is controlled by a published list of approved suppliers and products that is reviewed on a two yearly basis.

The Eskom specification for MV cable accessories has the following unique requirements:

- user as opposed to supplier defined standard accessory ranges i.e. to simplify stockholding etc.;
- the primary earthing connections (i.e. to the lead sheath or armour wires) in accessories are required to withstand the maximum prospective earth fault level and duration (i.e. 2 kA for 3 seconds). The connections are made using type tested mechanical arrangements;
- resin or mastic filled XLPE cable joints. The philosophy is to provide a water block preventing water migration through the joint. This is done in conjunction with the use of solid centre ferrules;
- top down measurement principle for three-core cable terminations i.e. the top of the stress control tube is positioned as close as possible to the bottom end of the lug barrel. This is illustrated in Fig. 2. The philosophy is to maximise the screened section of the termination tails and hence increase the clearance between the unscreened cores. The majority of termination failures found in Eskom have been attributed to electrical discharge between unscreened termination tails that have had inadequate clearances between cores.
- USCs that are suitable for use with the standard interface (i.e. 630 A type C M16 x 2) bushing. The USCs are used exclusively at 11 kV and are used in conjunction with an indoor termination. The USC bushing interface is an interference fit that provides a tight seal encapsulating the live bushing terminal. The purpose of this is to eliminate the creepage requirement that would typically be required if an exposed live terminal connection was made;
- SSCs that are suitable for use with the standard interface (i.e. 630 A type C M16 x 2) bushings. The SSCs are used exclusively at 22 kV and can only be used with XLPE cable. Again the SSC - bushing interface is an interference fit that provides a tight seal encapsulating the live bushing terminal however with a screened outer surface. The purpose of this is to eliminate both the creepage and clearance requirement that would typically be required if an exposed live terminal connection was made.

Compact switchgear (e.g. ring main units)

Extensible and non-extensible compact switchgear is required for two applications in the Eskom Distribution context i.e.:

- the provision of sub-switching stations; and

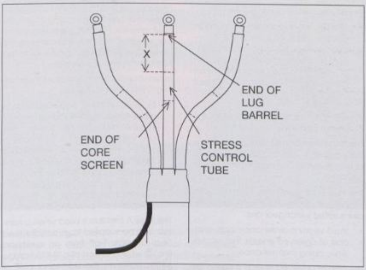


Fig. 13: Illustration of "top down" measurement principle.

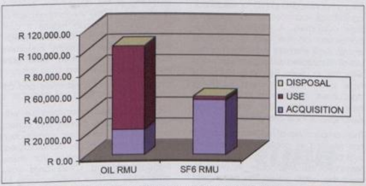


Fig. 14: Total cost of ownership of oil vs. SF6 gas-insulated switchgear.

Fig. 15: Front cable access to compact switchgear.

- provision of ring main units (RMU's) on the MV side of miniature substations (mini-subs).

At 22 kV there is no option but to use SF6 gas-insulated switchgear for the above applications as no alternative exists. However, at 11 kV the option exists of using either oil or SF6 gas-insulated switchgear. The Eskom decision to use either is based upon a total cost of ownership study that was done using the Electric Power Research Institute (EPRI) life-cycle cost management system (LCCMS) software.

The alternatives evaluated were:

- oil-insulated switchgear that undergoes routine maintenance every three years. The assumed maintenance frequency and average cost of maintenance is based upon Eskom experience with the installed base of oil-insulated compact switchgear;
- SF6 gas-insulated switchgear that is unmaintained.

The two alternatives were analysed for the acquisition, use and disposal phases of their lifecycle. The results are shown in Fig. 3.

The two most significant cost elements that make up the "use" cost factor for oil-insulated switchgear are:

- the 3 yearly maintenance cost; and
- cost of unserved energy that occurs while doing maintenance.

The cost of unserved energy is based on R/kWh figures provided annually by the Eskom Finance Group (12) for residential, agricultural, commercial and industrial type customers. A sensitivity analysis performed on the cost of unserved energy cost element indicates that the use of oil-insulated switchgear is only cost effective in areas supplying residential type customers. In areas supplying agricultural, commercial and industrial type customers SF6 gas-insulated switchgear is most cost-effective.

The compactness of modern switchgear has resulted in cable box dimensions that barely provide adequate space to terminate the MV cable. In order to assist the cable jointer the switchgear specification requires direct and full

Fig. 16: Type A MV compartment.

access to the bushings for cable termination. This is best illustrated by Fig. 15 showing how all metalwork and plinth in front of the cable boxes is removed allowing full access to the cable boxes.

Miniature substations (mini-subs)

In order to gain a competitive advantage the manufacturers of mini-subs have tried to design the footprint dimensions of their mini-subs below those specified as a maximum by NRS 004 (13). This practice has lead to mini-subs with varying footprints. In practice, a mini-sub that is significantly shorter than the plinth on site presents as much of an installation problem as one that is too long. In order to overcome this interfacing problem, Eskom has specified that the mini-sub footprint dimensions shall always be equal to the NRS 004 maximum dimensions.

In terms of the Eskom standard there are two types of mini-subs, i.e.:

- Type A, which is equipped with a dead-break isolating arrangement in the MV compartment. This arrangement allows for two incoming cables that can be connected together and either of which can be connected to the transformer; and
- Type B, which is equipped with compact switchgear in the MV compartment providing a RMU.

The type A mini-sub is used when a mini-sub is to be supplied from a radial feed (e.g. a cable T-off from an overhead line) or when the cost of a RMU is hard to justify. However the additional cost of unserved energy incurred during the operating of the dead-break isolating arrangement in the MV compartment of the type A mini-sub makes it cost effective only in pure residential areas. With the advent of many customers operating businesses from home, pure residential areas are rare.

Ground mounted transformers and CT-VT units

Ground mounted transformers (i.e. with MV and LV cable boxes) and current and voltage transformer combination (CT-VT) units are locally manufactured. The Eskom specification for these transformers and CT-VT units take advantage of local manufacturing by requiring the MV cable box dimensions for 11 kV units to comply with NRS 012 clearances for USC type terminations. The 11 kV cable box dimensions are therefore significantly larger than those supplied with imported compact SF6 gas-insulated switchgear. This is shown in photo 14. At 22 kV the dimensions of the MV cable boxes are required to provide adequate physical clearances to terminate the cable using SSCs i.e. no electrical clearances required.

Installations

Plinths

Although the use of pre-cast plinths is not new, the Eskom standard plinths used with compact switchgear and mini-subs are unique in terms of the removable sections adjacent to the MV cable connection areas. As mentioned previously the sections are removed on site to provide the cable jointer with full access to the cable boxes.

Safety measures

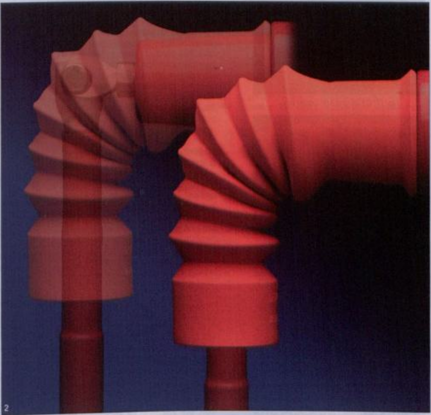
Protection from dangers resulting from an arc fault

Since 1998, the trend in the specification of metal clad switchgear has been to focus on the internal arc testing of the panels to ensure the safety of the operator during switching. Eskom has not only enforced this requirement for metal clad switchgear but also carried the philosophy through to the compact switchgear used for sub-switching stations typically found downstream of metal clad switchgear. The implementation of this philosophy at sub-switching station level is a good example of the evolution of a user requirement into a type tested product. This can be described as follows:

- In 1999 it was specified that all air and/or gas-filled enclosures of the compact switchgear (e.g. ring main unit) shall be internally arc tested and shall be fitted with suitable explosion vents to ensure overpressure release in a controlled manner to the atmosphere during an internal arc fault;
- although the above requirement was met by the suppliers of compact SF6 gas-insulated switchgear, there was little cognisance paid to the fact that the switchgear was being installed in enclosures that did not form part of the original type test. Furthermore no effort was made to design the enclosure in a way that complimented the internal arc proof design of the switchgear;
- in 2000 Eskom specified that the cable boxes should also be internally arc tested and that the design and construction of the enclosure (i.e. mini-sub housing or kiosk) shall complement the internal arc-test requirements of the compact switchgear i.e. the enclosure shall be designed for the safe venting (i.e. away from the operator) of gases released during an

Elastomeric insulating bushing boots for bushings up to 17.5 kV


1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1 RCAB insulating bushing boots, inline installation
2 RCAB insulating bushing boots, right-angled installation

Raychem

Raychem elastomeric insulating boots are moulded parts which fit over the connection between the cable lug and the inline or right-angled equipment bushing to improve phase-to-phase and phase-to-ground insulation. They are used in switchgear and transformer cable boxes where the air clearances are insufficient for normal operation, or to protect against flashover due to rodents or high humidity.

The non-tracking elastomeric housing has excellent erosion resistance, dielectric properties and environmental resistance, giving superb performance in areas of high humidity and electrical stress.

RCAB boots are quick and easy to install and work in combination with all Raychem termination product lines. The boot can easily be removed and reinstalled without additional material or tooling, allowing access to the bushing connection for test purposes.

Raytech Energy, 42 Industry Road, Olifantsfontein 1665, Tel. 011 - 316 1628, Fax 011 - 316 1680
Email: info@raytech.altron.co.za, website: http://www.raytech.co.za

tyco Electronics

Fig. 17: CT-VT unit MV cable box.

Fig. 18: Pre-cast plinth for mini-sub

internal arc fault. Enclosures housing compact switchgear were manufactured for Eskom that were designed with an arc proofing philosophy in mind. This is illustrated in Fig. 19; and

- presently at least two major manufacturers of compact switchgear have type tested their switchgear and kiosk combinations to prove that they meet the internal arc requirements of both Eskom and SANS specifications.

Protection of persons working on electrical equipment

Eskom has adopted a philosophy on all ground mounted equipment that ensures that all live parts within an enclosure are barricaded to prevent inadvertent contact being made by an operator requiring access. This includes the barricading of any unscreened MV insulation.

Conclusions

In the process of developing an MV standard for cable systems, Eskom has produced a number of unique solutions to the problems experienced in the past. However, there still remain areas that require further research and effort. These may be summarised as follows:

- In order to determine the long term performance of outdoor terminations and USC products used in Eskom, it is intended that natural ageing tests will be carried out at Eskom's insulator products test site at Koeberg in the Western Cape.
- The design of cable joints for PILC cable currently being sold in the market place are based upon a mastic or resin filled version of the traditional compound filled joint i.e. a collectively and not individually screened joint. Firstly, the joint design is not consistent with the cable design i.e. most users are using individually screened PILC cables. Secondly, as joints for PILC cables are not required to undergo partial discharge type testing, the mastic or resin used in conjunction with polymeric shrink tubes is not tested to ensure that it is discharge free.
- The problems experienced by Eskom in trying to train internal cable jointers on MV cable accessories that have instructions that vary significantly from one supplier to another have led to the development of a set of standard accessory installation instructions. Ultimately Eskom would like to see a formal accreditation system in place for cable jointing.
- Eskom is presently evaluating alternative MV XLPE cable designs with the intention of improving the cable's ability to prevent water ingress and subsequent water tree development.

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Fig. 19: Arc proofing of enclosures.

Fig. 20: Barricading of live equipment.

The next challenge: distance protection designed for ease of application

by A Edwards, SH Richards and DA Keeling, Areva T&D, UK

Distance protection has been a well-respected technique for many decades. With each emergence of a new hardware platform, this has allowed an incremental improvement in performance, most notably in recent years with the ability to implement distance characteristics by means of numerical algorithms in a digital relay. Continual research and development still produces incremental performance enhancements, however with the techniques and algorithms becoming more mature, the real additional benefits to the user are not always so apparent.

This paper describes the design approach for a new integrated distance protection and control relay. At the specification stage, the decision was taken as to what would benefit the user most. Several questions were posed and debated from the viewpoint of a utility technician, engineer, or operator.

- Am I generally happy with the performance of distance relays?
- Do I want to see new algorithm principles?
- How do I set and apply the relays to the power system?

The relay was born as a device that would use the most proven algorithms, with step enhancements only where it would bring an application benefit - using the benefit of hindsight since the last new product release. The main priority in the development was focused on making the product simpler to apply, operate and interrogate; and to establish fixed settings.

The paper summarizes that it is possible to implement a fully-performing distance relay for universal application, without increasing the complexity and training requirements into the realms of rocket science.

Basic requirements

Distance protection has two fundamental design requirements. Firstly, the relay must trip quickly for any genuine in-zone fault, to ensure that the system stability is not compromised and damage is minimised. Secondly, the relay must remain stable for all load and through-fed conditions. This latter point is particularly critical to avoid constraining the loadability of the line, and to avoid sympathetic unwanted trips from propagating through the power system under extreme conditions (such as power shortages, neighbouring circuit outages, power swings etc.). Good load avoidance is an essential defence mechanism in avoiding blackouts and unnecessary islanding.

A simplistic view of the trip and restrain (stable) requirements is shown in Fig. 1.

In the figure, the protected line impedance is shown, along with an extended area to the right where fault arcing resistance may appear. Typically, the amount of arcing resistance may be estimated from the van Warrington formula (1). The effective fault impedance measured by a distance relay may thus lie within this shaded region. In order to ensure tripping for all genuine faults, the relay characteristic must include the shaded region, for all zones up to and including the longest reaching zone (typically zone 3) reach point.

It is also evident that the relay must avoid the load area. The shaded load region shows the load impedance that may be presented to the relay under normal system operation, for example with the neighbouring circuit in a double circuit line being in-service. However, in many cases a lower minimum load impedance needs to be avoided, as shown by the unshaded extension of the load cone. This may consider circuit

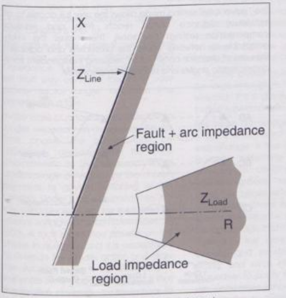

Fig. 1: Distance relay operating requirements.

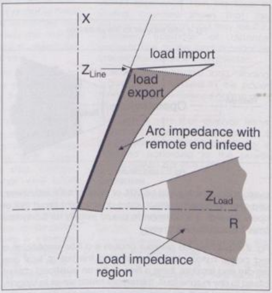

Fig. 2: Apparent arc resistance increase.

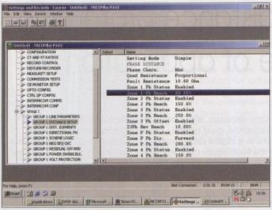

Fig. 3: "Simple" setting of zone reaches.

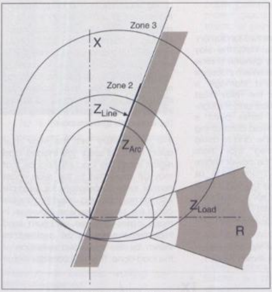

Fig. 4: Mho relay set for line protection.

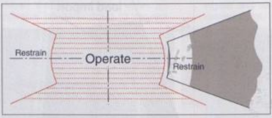

Fig. 5: Load binder "cone".

overloading, which could be 20% or more of full load current, and also the doubling effect where an adjacent circuit trips or opens. Overall, it is common to ensure stability for 2.5 to four times full load current flowing.

Fig. 2 shows how the previous analysis is a little simplistic. In a real power system. As each protected line has at least one remote end terminal, there is likely to be an additional current infeed to any in-zone fault. This remote infeed serves to magnify the apparent fault arc impedance as measured from one line end, with the effect becoming more pronounced as the fault position assumed moves towards the remote line end. Reference (2) details remote infeed effects.

Typically, this means that towards the remote end of the line, the relay trip characteristic must cover at least four times the van Warrington calculated resistance.

The relay requirement, however, remains unchanged i.e. firstly to trip for faults, with or without arc resistance included, and secondly to remain stable for normal load and overload conditions.

Relay settings

From the previous section it is straightforward to deduce that distance relay settings fall into two categories. The first category ensures tripping for all faults within the reach of the distance zones. Thus all settings here are related to the impedance of the protected line, and follow-on adjacent lines. The second category ensures load avoidance, commonly called "load blinding". All such settings are related to the load flow, ensuring that line loadability is not constrained.

The relay featured in this paper has been designed such that the user merely inputs the protected line data, and the load data, and the relay will then self-set accordingly. With approximately 50% of all investigated "maloperations" found to be the result of poor settings, then a product which has been designed with such simplicity should reduce the risk of typical errors occurring.

The relay uses an intelligent overview of the protected line to implement a "simple-set" option, and in doing so the user has only a few key parameters to set, rather than the proliferation of settings that can frequently accompany a multifunction relay. The ease of setting also translates to simpler commissioning and grading or selectivity.

Simple and advanced setting modes

In the majority of cases, "simple" setting is recommended, and allows the user merely to enter the line parameters such as length, impedances and residual compensation. Then, instead of entering distance zone impedance reaches in ohms, zone settings are entered in terms of percentage of the protected line (for example, zone 1 = 80%), as shown in Fig. 3.

Each zone can be set with a reach relative to the protected line, or if fine-tuning is required, an "advanced" setting option can be switched in later.

The "advanced" setting mode allows the user full access to all individual distance ohmic reach, filter and residual compensation settings per zone. This makes the relay adaptable to networks where the protected and adjacent lines are of dissimilar construction, requiring independent zone characteristic angles and residual compensation.

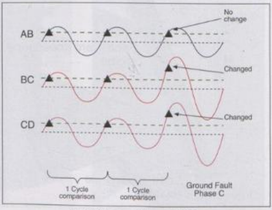

Fig. 6: Delta current phase selection.

In Fig. 3 it is noted that the relay in question can be applied with mho, or quadrilateral characteristics - to suit the utility's preference. When a quadrilateral characteristic is applied, zone resistive reaches must be set - the right and left-hand lines. Again, "simple-setting" is applicable, whereby the user sets a base arc resistance as a reference, and can choose whether to fix the same resistive reach coverage for all zones, or whether to set proportional characteris-tics. In the latter case, the relay fixes a reference fault at 100% of the protected line reach, and uses that to scale the resistive reach for the zone according to the same percentage as the reactance reach. Thus, all zones would share a common X/R (or Z/R) aspect ratio.

Taking the mho characteristic as a reference case, Fig. 4 illustrates the relay trip characteristics, where the relay is applied solely according to line protection constraints (i.e. ignoring loadability). It is evident that due to the length of the protected lines, zones 2 and 3 stray into the expected load area. This is unacceptable, as spurious trips would result.

This is an example of where one must consider the second category from previous discussions, and ensure load-blinding based on the expected load flows.

Load blinding

The relay in question uses an advanced load blinder which is designed to allow better resistive reach coverage. The blinder is basically formed from an underimpedance circle, with radius set by the user and two blinder lines crossing through the origin of the impedance plane. It cuts the area of the impedance characteristic that may result in an operation under maximum dynamic load conditions (Fig. 5).

The radius of the circle should be less than the minimum dynamic load impedance. The blinder angle should be set half way between the worst case power factor angle, and the line impedance angle.

In the case of a fault on the line it is no longer necessary to avoid load. So, for that phase, the blinder can be bypassed, allowing the full mho characteristic to be measured. Phase undervoltage detectors are the chosen elements to govern switching of the blinders. Under such circumstances, the low voltage could not be explained by normal voltage excursion tolerances on-load. A fault is definitely present on the phase in question, and it is acceptable to override the blinder action and allow the distance zones to trip according to the entire zone shape. The benefit is that the resistive coverage for faults near to the relay location can be higher.

The undervoltage setting must be lower than the lowest phase-neutral voltage under heavy load flow and depressed system voltage conditions. The typical maximum V < setting is 70% Vph-neutral.

Delta current detection

Many of the application difficulties for distance protection have historically been related to correct faulted phase selection. For example, in the case of a close-up reverse earth fault, a large amount of neutral current will be measured by the relay. This neutral current is also included in the earth loop impedance measurement for the unfaulted phases (by means of residual compensation), and the 120° displacement between phase voltages may allow the fault to appear in a forward trip characteristic.

Similarly, it can be difficult to ensure that the correct phase-phase element will be allowed to measure in the case of a double phase to earth fault, whilst restraining the involved earth pair zones. The latter is necessary to avoid overreach - particularly where quadrilateral characteristics are employed.

In this respect, the author's company decided to use a proven and successful technique, used in the previous two generations of their transmission line protection - delta current phase selection (3). Fig. 6 shows this principle.

Selection of the faulted phase(s) is performed by comparing the magnitudes of the three phase-to-phase superimposed currents. A single phase fault produces the same superimposed current on two of these signals and zero on the third. A phase-to-phase or double phase-to-earth fault produces one signal which is larger than the other two. A three phase fault produces three superimposed currents which are the same size. Fig. 6 shows how the change in current can be used to select the faulted phase for a CN fault.

A superimposed current is deemed to be large enough to be included in the selection if it is greater than 80% of the largest superimposed current.

The large advantage of using delta - which is effectively the magnitude of a step change - is that it is naturally biased towards detecting a fault. Faults produce a definite step change, whereas power swings and other unfaulted phase effects yield a lesser delta. Delta phase selection is used to control the distance elements, and has the advantage that it has no associated settings - the sensitivity is internally biased, and equally applicable for strong, and weak infeeds. The relay is thus easier to apply than designs which use underimpedance, overcurrent, or other starters to detect a fault.

Power swing blocking

Superimposed current is also used as the criterion to detect power swings. Power swings generate a continually changing current, and hence prolonged pickup of delta detectors. Pickup for longer than 50 ms is used to initiate power swing blocking, and keep relay stability. An advantage again is that no threshold settings or impedance starters are required - the technique works by its nature in all applications.

The relay tracks the profile of the delta current, and if at any point there is an unexpected step change in the prevailing delta, blocking must cease as a fault is now present. Thus, the trip time and zone selectivity for any fault inception during a power swing is as fast and reliable as had no swing been present.

Conclusion

This paper demonstrates how a distance relay designed for ease of application has fewer settings, and has a lower scope for accidental setting errors. A straightforward "simple-set" mode can allow zone reaches to be applied as percentages of the protected line. The Simple-set mode does not artificially place performance constraints on the application, and the use of proven techniques such as delta phase selection and power swing blocking allow universal deployment (for strong and weak infeeds, interconnected, and weakly interconnected systems that may be prone to power swings).

Relay settings can be split into two categories:

- those related to line protection/fault detection, and
- those to ensure load avoidance.

Recent experience from blackouts in several countries shows that the dynamic changes of load may result in undesired operation of distance elements due to the load impedance entering the distance characteristic.

A simple and effective load blinding technique as decribed in this paper forms an effective defence against such unwanted tripping.

The authors note that distance relays should not constrain the loadability of transmission lines. The distance relay is designed according to the power system needs - not vice versa.

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Pole mounted switches for coastal applications

by Geoff Auton and Johan du Preez, Linegear 2000

The paper will describe a range of switches designed for applications in highly saliferous conditions, including overseas conditions where sand deposits aggravate the situation.

Silicone clad composite glass cored insulators have been incorporated, which have to be carefully selected to withstand the cantilever forces experienced in switch designs, as distinct from the standard line applications. Designs have been made for use up to 44 kV insulation levels.

Drawings and photographs will illustrate typical applications, which are of very low mass compared to their porcelain counter parts.

Linegear 2000 has now accumulated nearly 15 years of experience for its range of outdoor pole mounted switchgear, which has been used in most regions of Southern Africa, and in all variations of climatic conditions.

Overseas experience has been wide, with 1000s of items in service in the UK, which has a hostile winter climate of cold, rain, ice and frost, and a significant number installed in the Middle East in hot, humid conditions with salt or sand contamination.

Nevertheless in the higher medium voltage range (24 - 36 kV) there is a growing preference for insulators with silicone sheds, for which extensive world-wide testing has demonstrated its superior surface characteristic. Hydrophobicity is the technical name used to describe the condition where a droplet of water on the surface of an insulator shed, stands-up, forming an almost spherical shape to the droplet. Most other material, particularly when contaminated in some way, may have drops in less than a hemispherical shape refered to as hydrophilic, and in a worst case may flatten down to completely wet the insulator surface (Fig. 1). This latter phenomenon has been known for very many years, long before the advent of silicone, and insulator designers used their knowledge and ingenuity to create sheds of varying shapes to even out the voltage gradients on the insulator surfaces. It was also important to provide wherever possible, sheltered areas where sand or salt deposits were not likely to accumulate. Insulators with smaller diameter sheds are interspersed with the larger sheds, not only to provide a sheltered area, but smaller diameter sheds will restrict the level of leakage currents, which are usually the mechanism of failure and performance criteria.

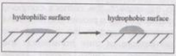

Fig. 1

The designs that are considered to be acceptable are well illustrated in Appendix D of SABS/IEC 815 on the subject of "insulators for service in polluted conditions", and the study of the surface characteristics of polymeric insulation materials is currently the subject of an IEC recommendation to analyse and quantify the nature of the droplets on the sheds of insulators. Readers who are more interested in the design and performance of hydrophobic materials are referred to an extensive amount of literature on the subject, and to the work of the South African Insulator Test Station at Koeberg.

Three phase switch disconnector

Switchgear for use under coastal pollution requires special design consideration, because the mechanical characteristics of the insulators have a strong impact on performance, especially the cantilever strength.

The majority of silicone insulators are moulded onto a pultruded fibreglass rod, which has high tensile strength. This is because the main application for them is as strain or suspension insulators in overhead line construction, where the core material is only subjected to tensile loading. For switch applications, the terminal insulators must have a higher cantilever strength to withstand the bending forces that can be applied to them as a result of the moving contact systems of the switch and the attached user connections. The moving insulator of the rocking-type of isolators or switch is a difficult proposition, because of the loading it is subjected to when opening and closing the main contacts.

The most widely used switch product on networks is the switch disconnector, which brings together all the problems at the same time and a new design, supersedes an existing extended porcelain design used by Eskom in the Western Cape region. The terminal insulators embody a larger diameter fibre-glass core, with a specific creepage of 31,5 mm/kV for the 24 kV system. Note that the contact drive insulator is a low mass silicone insulator which is used in a linear compression mode to drive the contacts to the closed position, and is used in its maximum strength mode of tension to pull open the contacts . This mechanical design is well proven by many years of service and the new insulators will readily fit into new system design plans.

Perhaps a larger problem exists in the overseas market, especially in the Middle East area of the Arabian Gulf, where the main pollutant is a combination of sand and salt, where even long creepage porcelain insulators have been a major maintenance problem.

The preferred insulant in the Gulf Region is the silicone insulator, but as the main distribution voltage is 36 kV, we now move into a new generation of switch-disconnectors, combined with drop-out fuses. Major schemes are in hand for

Fig. 2: 36 kV fuse switch combination.

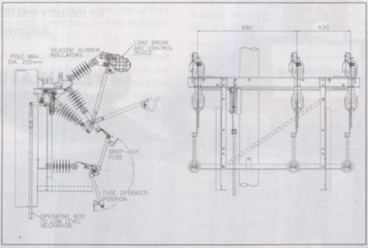

Fig. 3: 24 kV switch/fuse combination.

rebuilding the electrification networks of oil fields which have been decimated in recent wars in that area. The illustrations show designs at 24 kV and 36 kV which have been specially designed for these onerous conditions. The client has specified a specific creepage factor of - 40 mm/kV equal to 1440 mm and such insulators, being larger, need an even-larger diameter of the fibreglass core.

The whole switch becomes much bigger, and the length of the moving switch blade presents new problems. Such a switch, as per Fig. 2 was recently designed, and tested at the SABS/NETFA facility for both power frequency and impulse levels, resulting in a 52 kV level of insulation. The fuse switch combination was shipped to a world wide exhibition in Dubai, in the United Arab Emirates where it attracted an enormous amount of interest, and then sent on to Oman for the clients formal approval. A compact version of this switch/fuse combination for 24 kV is currently being finalised for a large order for the same region, which will also be available for local market applications.

Single phase applications

Regional electricity companies in the UK are retro-fitting large numbers of auto-reclosing circuit breakers (ARC) to improve the continuity of supply on their rural systems, and we were requested to provide a device which would allow an ARC to be connected on a pole which did not incorporate strain insulators.

The device was required to incorporate a strain insulator that could be used in two different ways:

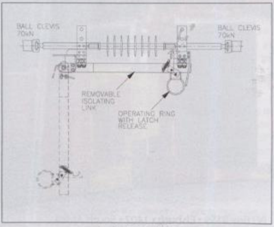

Fig. 4: 24 kV strain link.

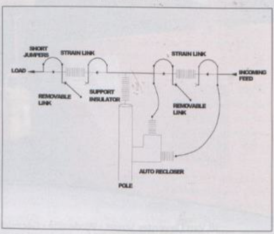

Fig. 5: Strain link diagram.

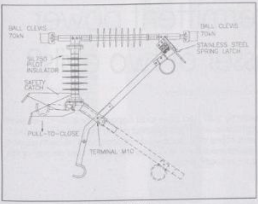

Fig. 6: Huklink.

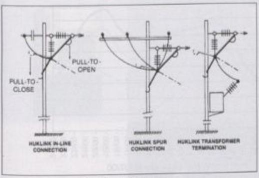

Fig. 7: Huklink diagram.

- To be fitted in the line at a normal in-line pole, so that the ARC could be bypassed when required by a pivoted link;
- To be fitted in series after the ARC, so that the pivoted, removable link could be removed to provide a visible isolating distance when it was necessary for men to work on the line. See Fig. 5.

The strain insulators will be fitted to existing lines, so low mass was essential, and the removable link is hook-stick operated and securely latched to prevent displacement by conductor vibrations. The components of the link and its contacts, are all components drawn from the three phase switches in the product range. This ingenious arrangement thought to be extremely cost effective and easy to fit, especially in a retro-fit installation where the work can be done by 'live-line' working techniques.

Eskom, has in the last decade used a product known as the Huklink, which is an in-line strain insulator or disconnector used in township developments, but in anticipation of their wider use on distribution lines a coastal application design has now been produced, with plans for a 36 kV version. This product is fitted at a strain pole, where it is connected in the line of the jumper conductor and includes two silicone insulators - one for the strain application and one as a pilot insulator for the pivoted link. Even though this device is mounted at the height of the conductors, they are easily operated by hook-sticks, with a pull down to open, and a pull down to close action.

This unit is now fitted with a safety catch, as used on 3 phase devices, to prevent operation by unauthorised personnel. Δ

No hot water, or intermittent power interruptions - the lesser of two evils?

by Barry Bredenkamp, Eskom Resources and Strategy

The picture of South Africa exceeding its installed peak demand capacity by 2007 and base load capacity by 2010/11 has been widely publicised over the last few months, (Fig. 1). 'Simunye' (the recommissioning of mothballed power stations), pebble bed modular reactors (PBMR), imported hydro-power from Cahora Bassa and many other supply-side options have all been eluded to as possible solutions for the provision of a 'comfort zone' to those pessimists out there who have expressed their dismay at this looming crisis in the energy sector in South Africa.

So what can local authorities do to help this situation, which in the main, is a problem for the national utility (Eskom) to deal with? (Although municipalities generally have to bear the brunt of wide-spread power outages in the residential sector of the South African market.)

Residential hot water load management (geyser control) is probably the quickest, easiest and most economical option for a municipality to implement. So why aren't all municipalities entertaining this concept? The answer is probably simply: bad experiences with unreliable technology, high initial capital requirements, insufficient resources to monitor and maintain the systems, irate customers with 'cold water complaints', no direct financial benefit for domestic consumers, inappropriate tariff signals from Eskom. And the list just goes on and on. Some politicians will even go as far as saying that it is unconstitutional to 'control' someone's geyser and/or hot water supply.

Fortunately, there now exists a number of solutions to overcome the technological, financial and institutional barriers referred to above. Furthermore, since 'hot water load' inevitably makes up the major portion of small-to-medium sized municipal peak loads, a 'win-win-win' solution can be achieved for all stakeholders, by developing and implementing an appropriate 'residential hot water load management strategy' for local authorities in South Africa.

This paper will therefore attempt to address the barriers mentioned above, with a specific focus on the technological challenges or solutions and lessons learnt during the development and implementation of a 'residential hot water load management strategy' in the areas of Table View, Mmabatho and Worcester. The paper will then go on to illustrate how this solution can and should contribute to the question referred to in the title of the paper: "No hot water or intermittent power interruptions - the lesser of two evils?"

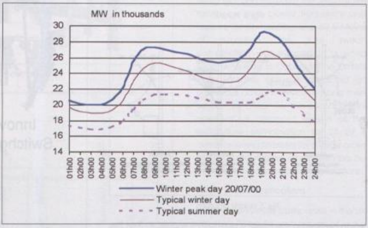

Fig. 1: Typical winter/summer national load profile.

Barriers

The widespread implementation of residential load management (geyser control), has over the years, been clouded in controversy and this has subsequently increased the barriers to entry for this particular option to shift load. These barriers include the following:

- The capital, installation and maintenance costs associated with the various technologies available for controlling geysers on a wide scale
- The security and control measures required to ensure that the equipment is not by-passed, which in turn, makes it almost impossible to accurately forecast load requirements
- The relatively cheap price of electricity associated with the 'all electric' household phenomenon, which is common in South Africa
- Limited and/or incorrect tariff signals or options available to municipalities and/or domestic users of electricity
- Surplus capacity and co-generation 'special offers' to municipalities, as a result of this
- More recently, the 'shared savings' option, offered by Eskom (DSM), to implement municipal geyser control projects
- Customer and political resistance to the concept of 'controlling' electricity consumption.

A customer perspective

From a customer's point of view, the only real electricity cost saving achievable from the geyser, is to use less hot water, limit the thermostat temperature, or reduce heat losses from the geyser, i.e. by using 'low-flow' showerheads, installing geyser blankets and pipe insulation, sharing of baths or showers or generally adapting one's lifestyle, e.g. taking a shower instead of a bath!

Furthermore, a vertical geyser could be installed, resulting in less heat loss from the smaller 'vertical plane' (surface area) of the geyser, than the typical conventional 3 kW horizontal geyser.


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However, the most important thing to note, is that the customer generally does not benefit directly from a large-scale municipal hot water (geyser) load control project, unless the particular municipality offers a 'Time-of-use (TOU)', tariff to its residential customers, or passes on the financial benefit (savings), to those customers through tariff rebates, deflated increases, etc.

Municipal requirements

For a municipality to contribute to alleviating the problem referred to in the introduction to this paper, and to access the DSM/NER funding mechanism available for projects of this nature, it is imperative that the following information is readily available:

Customer data

The feasibility of an energy management system is heavily dependent on the number of geysers utilized in the feasibility analysis. Obviously, municipalities expand and new customers are added to the financial system on a continuous basis. Therefore, regular, updated and accurate information is crucial, in determining the viability and contribution that a municipality can make, to alleviating the peak load problem in South Africa, for example:

- Total number of existing housing stock.
- Total number of switches already existing, where applicable.
- Current business plan, (expansion/ load forecasting, etc.).
- What technology to be used (radio/ ripple), and why?
- If ripple, what type of injection sets are suitable i.e.132 kV, 66 kV or 11 kV, (and why)?

Furthermore, there are two general approaches that can be used to verify the current geyser control deployment status in a municipality, namely:

Method one - geographic approach

Most municipal areas can be easily classified into their different respective socio-economic categories. From the different demographic classifications, it is generally known whether the domestic homes in a respective area would have geysers or not. Sample audits can also be executed to verify the category classification assumptions. Accurate information is essential to ensure reliable results. This can only be accomplished, if the following general information can be ascertained:

- Accurate area maps of the different wards (suburbs), in the municipality, as well as their respective demographic classifications.
- Is there running water and/or are geysers installed?
- If so, how many?
- Rated consumption of each i.e. amps.
- Is it on at the distribution board?
- What size geyser is being used (in liters)?
- Horizontal or vertical?
- Type of distribution board (old or new)?
- Is there space in the distribution board for a hot water load control switch?
- How many houses (representative sample), were used for the audit and why that many?

Method two - consumption or demographic approach

The presence or not of a geyser in a residential home can easily be established from the average monthly electrical consumption data available. This is very important, especially in the prepayment customer sector. Accurate information is essential to ensure reliable results. This can only be accomplished, if the following information can be provided:

- Analysis per ward (suburb), of the average consumer consumption data. This information can usually be obtained from the municipal financial system.
- Further sample audits can be executed, to verify the category classification assumptions.

Single line diagram of the supply

A single line supply diagram is essential to determine:

- possible supply (control) areas per supply point;
- points of supply to use as reference when controlling the geysers, (maximum demand control);
- supply voltages;
- different transformers and amount of each and how they are linked, to determine the number of injection sets required;
- substation space available for the installation of additional equipment;
- municipal electricity accounts (one winter and one summer month), of each point of supply;
- current and/or planned tariff structures and half hourly load profiles, (kW, kvar and kVA).

Basic information requirements

However, and in order to expedite applications of this nature, the following basic information requirements should also be considered:

- Brief background and history of the municipality in question.
- A comprehensive analysis of the municipal area, which includes all the sub-divisions, electricity supply points, residential area maps, as well as sample audits per ward (suburb), to verify the number of geysers installed in the respective residential areas.
- A comprehensive analysis of the Municipal billing data, to determine the number of households per ward (suburb), as well as their average electrical consumption. Sample audits per category or per ward should also be done, to confirm the geyser presence criteria from within the respective consumption categories.
- The geyser counts from the above analysis will then be consolidated, to provide a geyser count per ward, which is generally deemed to be accurate to within ten percent (10%), of the actual data.
- Risk identification and possible mitigation factors.
- The preferred sequence of installation, e.g. areas where capacity, cables and equipment are the most constrained, etc.
- Availability and identification of possible redundant municipal or local resources that could be trained, for installation purposes, ie. job creation opportunities.
- Size of existing load management system, if any, e.g. number, of injection sets, controllers, relays, metering points, etc.
- Potential for expansion, if existing, or in the case of greenfields projects, the total estimated number of geysers within the supply area.
- Makeup of supply area, e.g. one metropolitan town or number of smaller towns consolidated into one metropolitan council.
- Current bulk purchase tariff of each town within the supply area, if more than one, e.g. NightSave, MegaFlex, etc.
- Plans or timeframes for bulk purchase tariff migration, if any.
- Number of supply points.

- Level of notified maximum demand (NMD), for each supply point, (a copy of a winter bill per supply point would suffice).
- Project approval level or delegation of authority, i.e. management committee, executive mayoral committee or local council approval or alternatively, what steps need to be followed for final contract signature/s, project implementation and estimated approval timeframes.

Project options

The scope of projects generally include one of the following two options:

- The refurbishment and/or expansion of existing load management systems:
- Greenfields implementation (completely new systems), where no existing load management systems are presently in existence.

Where functional systems already exist, expansion or refurbishment can, as far as possible, be implemented, using the existing equipment as a foundation for the more efficient systems presently available on the market. In the case of greenfields sites, an open tender based on the 'generic load management specification', provided by Eskom DSM is followed. However, it is possible to allocate preferred supplier status to one or other technology or manufacturer, if required by the municipal tender or procurement policy, provided that such equipment meets the required minimum technological and quality requirements.

The cost of each project will be funded through a grant provided by Eskom DSM. The release of grant monies is subject to the overall project meeting the minimum criteria laid down by Eskom (DSM) and the NER, which is measured by looking at the R/MW , resulting from the implementation of such a project. (This budget is administered by Eskom DSM on behalf of the National Electricity Regulator (NER)).

The entire process is managed and regulated by two back-to-back performance contracts between the parties involved. The first will be between the municipal-appointed, authorised Energy Service Company (ESCo) (or project manager or consultant), and the municipality or local supply authority concerned. And the second contract between municipality and Eskom (DSM), i.e. the channel through which the NER-funding will flow. These contracts will cover aspects of system operation, maintenance and performance, with committed power (MW) reduction targets.

Procurement

In the case of greenfields projects, Eskom (DSM) will supply a generic load management system specification for evaluation. Eskom (DSM), the ESCo and the municipality will develop the tender technical specification jointly, for issues on open tender. The ESCo will develop the final specification document for ratification by Eskom (DSM), and the municipality.

Where an existing, functional system is in place, similar, compatible equipment will be utilised as far as possible, for the expansion or refurbishment of the existing system.

Marketing and customer education

All parties generally consent to liaise and co-operate with each other, to ensure that the project is properly communicated to all stakeholders in the value chain and that customers are thoroughly informed, on the reasons for, and the implications of such a project in their area. Eskom (DSM) may even cover or at least contribute towards the marketing costs, inline with pre-approved budgets and guidelines.

Environmental issues

Detailed information is available on the installed capacity, efficiency and operating characteristics of Eskom's generating facilities; fuel consumption by facility; and generation facility dispatch policies. Eskom prepares annual estimates of fuel consumption, water used, ash produced and emissions released due to the production of electricity from each of its facilities.

Estimates of reductions in emissions can be calculated by multiplying emissions factors per kWh of electricity produced by the number of kWh of electricity produced by each generation facility. In South Africa there is a mix of nuclear, hydro and coal-based thermal generation. However, it is widely accepted that coal is the marginal generation source, so emissions reductions are based on an assumed reduction in coal use. This, in turn, will assist in calculating the potential 'carbon credits', as a result of the emissions reduction in greenhouse gas emissions (GHG), because of the reduction in 'peak demand' on the national grid.

However, if funded through this mechanism, 'carbon credits' emanating from the reduction in emissions as a direct result of the implementation of the DSM residential hot water (geyser) load control project, will accrue solely for Eskom's benefit in the municipality in terms of the UN Framework Convention on Climate Control (Kyoto Protocol).

Ownership, operation and maintenance of equipment

The participating municipality will retain ownership of all equipment acquired by the ESCo on behalf of the municipality, using NER/Eskom funding in respect of the proposed DSM project and installed by the ESCo and/or municipality, that reduces the electricity consumption of the municipality.

The daily operation and maintenance of the entire load management system will be the responsibility of the municipality, unless otherwise negotiated with the ESCo. These costs will be borne by the municipality, using the savings accrued by the project, or by the manufacturer or supplier of the equipment, in terms of any guarantees that may be applicable or negotiated between the parties concerned. Daily operational procedures and system parameters will be performed according to agreed guidelines between the ESCo, Eskom (DSM) and the participating municipality.

Measurement and verification

The monthly savings will be calculated by way of a predetermined methodology, which roughly involves the establishment of a baseline to which the actual measured load profile is compared, to determine the savings.

A measurement and verification (M&V) plan is then developed by an independent M&V body, which has been established by Eskom (DSM), for this purpose. The plan will cover all aspects of the M&V process, from baseline calculation methodologies to metering to periodic plan review points (notch testing), and if necessary, dispute resolution mechanisms.

This plan must be ratified by all parties and executed by the National Monitoring and Evaluation Centre, (NMEC). The NMEC will also perform daily and monthly data retrieval and verify the monthly savings calculations. All parties will then ratify or approve the monthly savings according to a pre-approved process and review the actual against the planned, or calculated, savings submitted in the original proposal.

Energy and peak savings

The national DSM plan presently indicates a target of 43 MW of shifted peak demand per annum, over the next 10 years (2004 to 2014). Although this target could change depending on prevailing circumstances, the information gathered from some of the initial work in the Mafikeng and Mmabatho projects, indicate that these targets are quite easily attainable.

Benefits, risks and lessons learnt

The lessons learnt from the projects referred to previously, also highlighted a number of additional benefits and risks.

The Table View (1998) project, which was one of the initial DSM-related initiatives in this area, has emphasised the need for proper control and monitoring interventions to be put in place, to ensure success, as it now 'appears' that the majority of relays in the area have either been by-passed or failed over time.

Similarly, the recently approved Worcester (2003/2004) project has been a test-case for overcoming the immense and time consuming bureaucracy and protocol to deal with, when so many roleplayers (and fairly large budgets), are involved. This project also provided valuable lessons in terms of making provision for long, and exchange rate related, procurement processes that need to be adhered to, in streamlining the entire process.

The Mmabatho (2002/2003) project emphasised the need for post-implementation commitment to utilising, optimising and maintaining the network, which in itself, is a huge asset for any municipality, i.e. from senior management, right down to the call centre and clerical or billing staff involved in the process. Training of local staff responsible for maintaining the system and dealing with customer related enquiries, is crucial for the overall success of projects of this nature.

An obvious risk from a municipal perspective, could be where larger commercial enterprises like hotels, hostels, etc., who are billed on a time of use (TOU) tariff, could result in a net 'revenue loss', i.e. depending on the structure of such a tariff.

However, the overall benefits definately outweigh the risks, and could potentially provide participating municipalities with a competitive advantage, during the transitions towards regional electricity distributors (REDs).

Conclusion

South Africa is no different from the rest of the world, in as far as the increasing demand (and rising costs), of energy is concerned. Taking the 2003/2004 winter unplanned outages into consideration, then we see more similarities with California, New York, Italy and other major, developed countries, who have also recently experienced serious 'brown-and-black outs'

However, what does differentiate South Africa from most other energy intensive countries, is the phenomenon of the 'all electric' home, i.e. we do not have access to natural gas for heating purposes, and solar water heating still remains a relatively unknown and uneconomical option for residential water heating.

This scenario, coupled with the latest innovations in technological development in the field of residential hot water load management equipment, presents this country with a unique opportunity to take the lead in this area of demand side management (DSM), worldwide. Add to this, the 100% financing option available from the NER/Eskom (DSM), for this activity, then there should be no reason why all municipalities are not taking full advantage of this unique opportunity, in a rapidly evolving electricity distribution sector, i.e. before the capacity situation in South Africa necessitates legislation in this regard! The only remaining question begging an answer relates to what should be done in the unlikely event of something going wrong and customers experiencing cold water? Well, in the short to medium term, the choice remains: 'Limited hot water shortages, or regular and intermittent power interruptions... which is the lesser of two evils?

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Equipment theft mitigation - the Eskom experience

by A Bekker, Eskom Distribution Technology

Eskom has experienced conductor theft since the late 1980s. The mitigation strategy followed up to 1994 was to replace copper conductors with aluminium conductors, which paid off until the recent increase in the price of aluminium. Eskom has therefore had to review its strategy since the incidents have increased significantly in the last 3 years.

This paper describes the strategy followed by Eskom to address the scrap market, apprehend the conductor thief and to apply technology to secure its assets. Eskom was extremely successful in that theft levels have now dropped to pre-2001 levels.

The first part of the paper tries to quantify the problem and to examine the market structure and operation of syndicates in this market. Secondly, Eskom's strategy is discussed in detail and success stories are shared. The application of the technology of alarm systems and security systems are also discussed. Finally, an industry approach to the problem is proposed.

The scrap market

An analysis of the scrap market (Fig. 1) reveals the fact that conductor theft is in essence driven by a need created by market forces, such as the demand for aluminium in today's industrial world. An electrical conductor contains 99,5% pure aluminium with several uses in the manufacturing of aluminium alloys and as a de-oxidizing agent in the steel industry. Any strategy to combat conductor theft can therefore only be successful if the whole market is addressed in the strategy.

Research revealed the following contributing factors to theft of non-ferrous metals:

- Socio-economic problem of increasing numbers of unemployed people
- Increasing numbers of illegal immigrants becoming involved in thefts
- Involvement of organised groups/ syndicates in thefts
- Increasing demand for copper and aluminium locally and internationally
- Insufficient control and legislation regarding processing, sale, import or export of non ferrous metals
- Low risk involved in accessing some of the networks (low voltage)
- Accessibility to networks.

The most important contributing factor has been identified as perpetrators having a readily available scrap market to sell stolen material, which is routed through various ways back into the chain of processing, manufacturing and supply. Evidence was also gathered that large amounts of stolen material are exported to markets abroad.

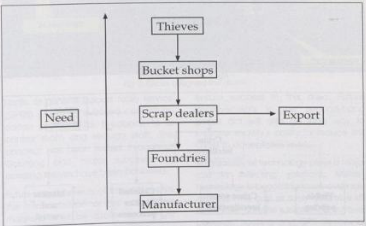


Fig. 1: Scrap market structure.

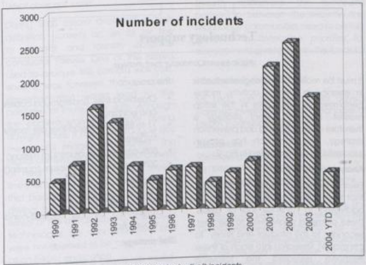


Fig. 2: Conductor theft incidents.

In the early 1990s, Eskom experienced an upsurge in conductor theft, but the crime was perceived as copper related. The main thrust of Eskom's theft prevention was thus aimed at removing copper from Eskom's network, with little attention paid to the wider market. Initial results proved this a successful strategy and incidents decline until 2000. At this stage, the price of aluminium increased to exceed the value of copper for equal weights. Conductor thieves changed their focus and a 200% increase in conductor theft was experienced. See Fig. 2.

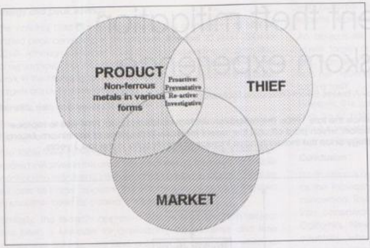


Fig. 3: Strategy elements.

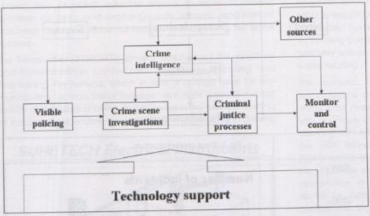


Fig. 4: Eskom Conductor theft strategy.

It must be realised that conductor theft is in essence a criminal activity, mainly performed by syndicates in the scrap market. Eskom's current strategy is therefore a crime fighting and prevention strategy. This approach has proven successful as demonstrated in Fig. 2.

Analysis of the problem

Eskom's experience led to the realization that three critical elements need to be addressed to minimise loss of assets. These elements relate firstly to the thief, secondly, to the product and finally to the market. Research into each of these elements revealed the following interesting facts:

The thief

- Large numbers
- Steal for survival
- Minimum risk - lines in remote areas
- 94% unorganised - responsible for 40% losses
- 6% organised syndicates responsible for 60% losses

The product

- Overhead lines, underground cables and earthing
- 11 to 88 kV overhead lines are mostly targeted
- 60% copper, 40% aluminium (history)
- 30% copper, 70% aluminium (current)

The market

- ± 4500 "bucket shops"
- Regulated by the Second-hand Goods Act

The strategy

Eskom developed a strategy to combat conductor theft. The crime prevention strategy relies upon intelligence gathering and research to ensure effective policing and related processes. Eskom also ensures that the full criminal justice process is followed, often with support to local prosecutors and police.

The Eskom conductor theft strategy (see Fig. 4) consists of the following elements:

Visible policing

- Line patrol (security related)
- Observation
- Arrests

Crime scene investigations

- Information gathering
- Criminal/syndicate profile

Criminal justice process

- Bail
- Evidence and witnesses
- Support to prosecution

Monitor and control

- Follow up after release

Crime intelligence

- Market research and analysis
- Database and incident recording system
- Informants

Technology

- Enabler
- Conductor marking
- Alarms
- Camera equipment
- Alternative materials

Industry co-operation

Industry-wide co-operation has been established by all role players. The non-ferrous theft combating committee (NFTCC) is an integrated body of key role-players that provides strategic guidance and direction for the process of prevention and eradication of theft of non-ferrous metal so that quality of supply of strategic services can be ensured to the benefit of all the people in South Africa.

Role-players currently represented on the national committee are as follows:

- Eskom
- Telkom
- Transnet (Including Spoornet and Metrorial)
- Chamber of Mines representing several mine groups
- Recycling Industry
- Manufacturing Industry
- City Power Johannesburg, several metros and municipalities.
- SA Police Services
- Department of Justice (including the National Prosecuting Authority and Directorate of Special Operations)
- Department of Trade and Industry
- Customs and Excise
- SARS
- Business Against Crime

The NFTCCs strategic direction is described below.

Establishment of effective management information systems

- Database
- Intelligence cycle

Effective co-operation and commitment

- Policing of hot spots
- Joint operations

Standardised interpretation and application of relevant legislation

- Common understanding
- Standardised application
- Enforcement

Establishment and co-ordination of formal regional structures

- Regional committees & standardised agenda
- Monthly reporting

Effective marketing and communication (internal / external) initiatives

- Strategic partnership with key stakeholders
- Newsletter
- Awareness campaign

Technology as an enabler

Material

Eskom's unique conductor marking scheme asssited at numerous court cases to establish ownership of material. Scrap conductor, generated by Eskom, is disposed of in a controlled manner. Eskom appointed a sole supplier agreement to ensure that no illegal conductor can enter the market. Similar approaches is used by Transnet.

Conductor doping, currently being researched, provide for opportunities to contaminate aluminium to render it worthless to the scrap market.

Substation technologies

The purpose of applied technology in a substation environment is to improve access control, monitor intruder and Eskom staff movements and to initiate rapid deployment of security staff. The fact that a substation environment is a well defined and controlled environment leads to effective deployment of modern infra-read monitors, security fences and alarm systems. A system of grading of substations in terms of risk has been developed and is deployed throughout Eskom.

Earthing of structures and equipment is done through the structures' steel and via copper conductors in the concrete plinth.

Line technologies

Line alarm technology, as developed by Eskom is shown in Fig. 5. Detection of a conductor theft event takes place through a mechanical tilt sensor, which relays information to the alarm unit.

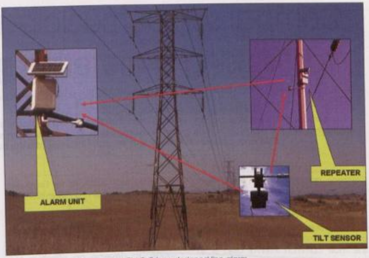


Fig. 5: Eskom designed line alarm

Radio or general packet radio service (GPRS) - cell phone based - communication provides for feedback to a control room and security staff. The concept has been tested throughout Gauteng and major successes in arresting thieves have been achieved.

Future improvements of this unit involve the miniaturization of the unit. These mobile units will be applied by a single operator under live-line conditions.

What does not work!

During 2003 Eskom deployed a high definition camera on an 88 kV line to monitor and identify potential conductor thieves. One of the criteria used to procure this camera was cost, since it was foreseen that successful implementation would lead to the purchase of more such units. Although the camera worked perfectly during daylight hours, it failed to produce any meaningful images after sunset. The digital camera technology used consists of near infrared, which has severe limitations in darkness. It was also found that background lighting, such as cars driving by, easily saturated the CCD sensor of the digital camera. Alternative technologies are very expensive and were not deemed to be cost beneficial as an Eskom application.

Conclusion - the road ahead

Conductor theft has been targeted as a key strategic issue by all role players. This has led to a major reduction in the number of incidents but the problem has by no means been eradicated. It is therefore important that organizations remain vigilant and current projects must be resourced and funded to ensure success in this area. Future improvements in the second-hand goods act will also go long way to improve society's ability to reduce this crime to acceptable levels.

Affordability of technology plays a major role in selecting solutions. Military technology is becoming more available although the cost of such systems is still prohibitive. Satellite surveillance, infrared cameras, tracking and GPS devices all have promises of enhancing current security operations. The successful partnership between the security and technology communities need to be fully explored to determine priorities for development and to obtain the funds for future projects.

Acknowledgements

Mr. Leon van den Berg, senior advisor (forensic investigations) and manager of Eskom's conductor theft unit.

References

The following Eskom documents have relevance:

(1) DISASADJ6rev0: Standard for security requirements at distribution substations
(2) SCSSCAAR4rev0: Specification for non-lethal electrified fence structure and associated equipment for distribution sites
(3) DISSCABM6rev0: Specification for cctv surveillance systems at distribution substations
(4) DISSCABL1rev0: Specification for intruder alarm systems used at distribution substation
(5) DISSCABL2rev0: Specification for security fences at distribution substations
(6) DISSCABK9rev0: Specification for electronic access control at distribution substations
(7) DISSCABK1rev0: Specification for infrared detectors used at distribution substations
(8) DISSCABM7rev0: Specification for overhead conductor alarm systems used on distribution lines. Δ

Comparison of municipal and Eskom tariffs using a metering spreadsheet

by Stephen Delport, Ekurhuleni Metropolitan Municipality

The purpose of this paper is to point out the structural differences that inherently exist in the various Eskom and municipal electricity tariffs. It is important to note that where comparisons of tariffs are displayed, the tables were compiled during May 2004, and increases in tariffs or tariff structural changes after this date will not be reflected.

Common amongst almost every electronic meter, and higher level billing system, is the ability to save accumulated energy values within the meter at regular intervals, the so-called "metering interval", over which energy values are integrated. The most common interval used is 30 minutes.

Each type of electronic meter is provided with some form of meter specific software. This software, and some hardware typically a notebook type of computer, are used to programme the meter, retrieve data, and to a limited extent process data.

Some packages that can read a variety of meters do exist, but in some instances, at a price that only larger utilities can afford. There are also annual costs involved to update these packages as tariff rates are increased and tariff structures change.

What is common to most of the meter software packages is the ability to output the profile data to a compatible format that can be imported by commonly available spreadsheets.

This enables the (experienced) spreadsheet user to analyze data and produce meaningful output.

From an article published in Elektron, a journal of the SAIEE, March 1997, page 29, entitled: "The window into electricity usage and costing", the following two statements are quoted:

- "The use of spreadsheets is however not all that effective where large amounts of data are involved, or advanced analysis is required e.g. time-of use (TOU) analysis"
- "Those experts who are able to use the programming languages built into the modern generation spreadsheets, quickly run in to bottlenecks and timing issues: An early attempt to run a spreadsheet based, TOU analysis on one year's data, ran for 13 hours on a 100 MHz Pentium based computer"

An innovative set of spreadsheets to simultaneously calculate three different electricity tariff accounts for Ekurhuleni, City Power, Tshwane and Eskom has been developed.

With the aid of a modern spreadsheet, extensive use of the so called "and", "or", "if" mathematical statements has been made, to develop an effective tool whereby various bills are generated directly from imported monthly profile data from a variety of commercially available electricity meters.

The spreadsheets also have the capability to provide for public holidays that would be treated as a Saturday or Sunday and automatically change the profile data to the applicable standard or off-peak energy or demand values. This means that meters in the field do not have to be updated annually with new holidays.

The accuracy of the input data is of prime importance. Experience and knowledge of problems that may be encountered is required as the profile data is financially related and used to create bills, and this therefore requires that extensive checks need to be applied.

Through the application of the spreadsheet, some minor discrepancies have been discovered in bills generated from the same set of profile data within different programme applications. The spreadsheet ensures that customers are billed correctly as far as practically possible.

It is important to note that the discrepancies found were in no way related to the meters and their wiring, but were rather due to programmable and/or tariff structural features misinterpreted. (Gaps in data, incorrect alignment of data, public holidays, duplicated data, garbage in garbage out principle, etc.)

Tariff comparisons:

The following categories of tariffs will be compared and discussed in this paper:

Ekurhuleni Metropolitan Municipality

- Tariff C: (kWh and kVA demand tariff), and
- Tariff D: (TOU tariff > 500 kVA)

City Power of Johannesburg

- Large customer demand tariff (medium voltage): (kWh and kVA demand tariff), and
- Large customer time-of-use tariff (medium voltage): (TOU tariff > 100 kVA)

City of Tshwane Metropolitan Municipality

- 11 kV supply scale tariff: (kWh and kVA demand tariff), and
- 11 kV supply time-of-use tariff (TOU tariff > 750 kVA)

Eskom

- NightSave urban: supply voltage > 500 V and < 66 kV; voltage surcharge 10,07% and transmission surcharge 0% (kWh and kVA demand tariff), and
- MegaFlex: supply voltage > 500 V and < 66 kV; voltage surcharge 10,07% and transmission surcharge 0% (TOU tariff > 1000 kVA)

However, the spreadsheet applications developed will also generate bills for the following tariffs:

Ekhurhuleni Metropolitan Municipality

- Tariff C1.2 off-peak 21:00 to 07:00 on weekdays. (kWh and kVA demand tariff), and

City Power of Johannesburg

- Large customer demand tariff (low voltage and high voltage): (kWh and kVA demand tariff), and

City of Tshwane Metropolitan Municipality

- 11 kV supply scale: time-of-use (> 750 kVA, 11 kV supply)

Eskom MegaFlex and NightSave tariffs

- On all voltage levels and different transmission surcharge levels as well as MiniFlex on all supply voltage levels, all voltage surcharges, and all transmission surcharges (TOU tariff)

Load factor (LF)

It is important to understand how the load factor will be calculated when it is used in any tariff structure to determine a customer electricity bill.

NRS 057-1:2001: Electricity Metering, defines load factor as follows:

A factor that allows for the average period in which an appliance uses maximum load, derived by average load divided by the maximum demand. (NRS-034-0)

NRS 034-0:2001: Electricity Distribution - Guidelines for the Provision of Electrical Distribution Networks in Residential Areas, defines load factor as follows:

A factor that allows for the average period in which an appliance uses the maximum load.

Generally load factor is calculated as follows:

$$LF = \frac{\text{kWh} \times 100}{(\text{max. demand kVA}) \times \text{hours in month.}}$$

Ekurhuleni Metropolitan Municipality defines load factor in their tariffs as follows:

Load factor is the average demand of a load divided by the maximum demand of the load over the billing period, i.e.:

$$LF = \frac{\text{Average load}}{\text{Peak demand}}$$

Ekurhuleni Metropolitan Municipality has coupled a rebate depending on a certain load factor to their tariff structures. It has therefore now become important to clearly define the way in which the load factor will be calculated to customers.

The above definitions do not seems to clearly define how load factor is to be calculated and therefore the methods used to calculate load factor may give varying results.

To demonstrate the difference in answers that can be obtained by the various methods, the following two examples are used from the same set of profile data:

LF as generally calculated:

$$= \frac{\text{kWh} \times 100}{(\text{max. demand kVA}) \times \text{hours in month.}}$$

$$= \frac{1\,684\,656 \times 100}{3331 \times 24 \times 30.}$$

$$= 70{,}24\%$$

LF as calculated in Ekurhuleni:

$$= \frac{\text{kVAh} \times 100}{(\text{max. demand kVA}) \times \text{hours in month.}}$$

$$= \frac{1\,979\,529 \times 100}{3331 \times 24 \times 30.}$$

$$= 82{,}54\%$$

Thus the difference in load factor is: 82.54 - 70.24 = 12.3%

To ensure a comparison of apples with apples, it is suggested that the second calculation method be used to determine the load factor of a customer.

It is also important to note that in case of a power failure on the supply authority network, the actual hours to be taken into consideration for calculating the load factor may differ from the actual hours in a month.

(NRS 071: 2004 draft: Automated Meter Readings for Large Power Users, will probably also address this issue, and Ekurhuleni has requested that the load factor be clearly defined).

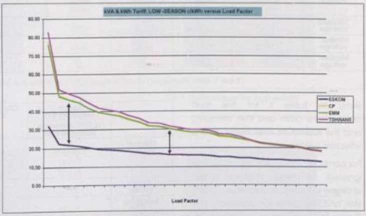


Fig. 1: Low season months.

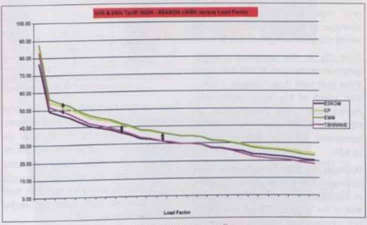


Fig. 2: High season months

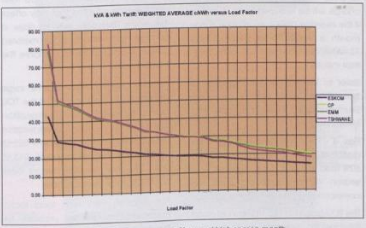


Fig. 3: Weighted average of low and high season month.

	Eskom	City Power	Ekurhuleni	Tshwane		
	NightSave kVA	>100 kVA	>100 kVA	>200 kVA	≥ 13 kWh/kVA	
	10,07% Voltage surcharge		3,00%		Energy charge reduced if daily consumption is equal or greater than 13kWh per kVA of the max demand/month	
Medium voltage	1491,45	R552,00	R256,25	R333,31		
Medium voltage	R15,60	R48,00	R46,31	R51,51		R/kVA
	R45,92	R48,00	R51,97	R51,51		R/kVA
Medium voltage	10,46	11,67	12,61	12,01	11,15	c/kWh
Medium voltage	13,92	17,57	16,32	12,01	11,15	c/kWh
Medium voltage	0	3,09	0	0	0	c/kvarh

Table 1: Tariffs: Ekurhuleni (EMM), City Power (CP), City of Tshwane and Eskom MegaFlex.

Refer to Table 1 for the tariff comparisons (kWh and KVA demand) and the impact of load factor on the effective c/kWh.

For comparison purposes the author has ignored all fixed charges (basic charges) in Table 1 and considered only kVA and kWh costs for Ekurhuleni, City Power, Tshwane and Eskom, in order to compare the effective c/kWh rate, low and high season, and weighted average, at different load factors. The results are given in Fig. 1, 2 and 3.

From Fig. 3, the weighted average graph, it can be seen that the so-called three part tariff (basic charge + kVA + kWh costs) of the three metropolitan municipalities under consideration, do not differ much when the c/kWh is compared for load factors from 0 to 0,55.

However, for load factors higher than approximately 0,55, a specific condition in the Tshwane tariff states: "provided that in the case of a consumer who is not supplied with electricity under the off-peak supply scale, the said energy charge will be reduced to 11,76 c/kWh if the average daily consumption in any month is equal to or greater than 13 kWh/kVA of the maximum demand in that month.

Refer to Table 2 for a comparison of time-of-use tariffs (TOU) between Ekurhuleni, City Power, Tshwane and Eskom MegaFlex.

Figs. 4 - 11 compare a typical 5 MVA customer account with an approximate 80% load factor for the high and low season months and indicates the corresponding different pricing signals.

The TOU graphs of Fig. 12 were obtained for a specific consumer with an average

	Eskom MegaFlex kW 10,07% surcharge added to tariff	City Power kVA	Ekurhuleni kVA less 3% discount on tariff	Tshwane
Medium voltage	R2 613,86	R2 675,76	R1 025,00	R348,31
	R11,37	R33,15	R13,65	R53,57
	R11,37	R33,15	R13,65	R53,57
Peak c/kWh	55,52	45,03	80,60	27,62
Standard c/kWh	16,03	17,49	23,27	9,04
Off-peak c/kWh	9,50	12,54	13,79	7,21
Peak c/kWh	17,01	19,42	24,69	27,62
Standard c/kWh	11,26	14,33	16,35	9,04
Off-peak c/kWh	8,50	11,87	12,34	7,21
c/kvarh	3,17	0	0	0

Table 2: Comparison of time of use tariffs (TOU): Ekurhuleni Metropolitan Municipality, City Power of Johannesburg, City of Tshwane Metropolitan Municipality and Eskom MegaFlex.

kVA demand reading of 4 296 kVA and average consumption of 2 558 010 kWh per month over 12 months with an average LF of approximately 78,5% accordingly. These graphs clearly demonstrate the different impacts on a specific customer account that the different tariff structures under consideration will result in.

Due to the complexity of a TOU tariff and the various factors that may affect the results, the only way to draw a conclusion is to actually model metered data in a programme to compare the actual results.

However due to the relative large differences in the kVA part of the TOU costs between the metropolitan municipalities under consideration (Tshwane - R53,57, City Power - R33,15 and Ekurhuleni less 3% included - R13,65 per kVA) the following broad base guidelines may be applicable:

For relatively very high load factor customers, Tshwane will probably be the lowest, and as the load factors decrease to a level in which most customers fall, the lower kVA cost of Ekurhuleni will result in this municipality offering the lowest prices for TOU customers.

It is also note worthy that for relatively high load factor customers, the Tshwane TOU tariff results in lower customer prices than Eskom MegaFlex, without a definite higher pricing signal during the winter months, June, July and August.

It is further also to be noted that City Power TOU tariff has four high season months (May to August) versus Eskom three months (June to August).

Future tariffs

Future tariffs charged to larger customers will probably be cost-reflective and include geographical differentiation resulting from the relative location of the markets from electricity generation plants as well as the physical layout of the country.


ELSTER
Kent Metering (Pty) Ltd

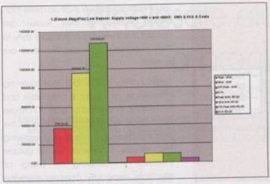


Fig. 4: Eskom MegaFlex: low season.

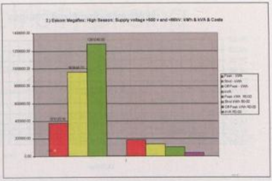


Fig. 5: Eskom MegaFlex: high season.

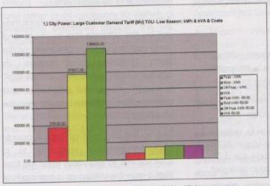


Fig. 6: City Power large customer TOU tariff: low season.

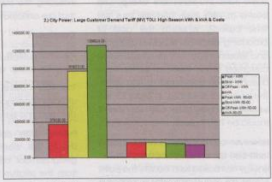


Fig. 7: City Power: large customer TOU tariff: high season.

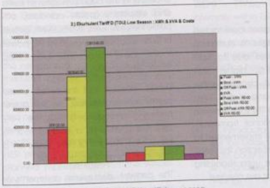


Fig. 8: Ekurhuleni TOU tariff: low season.

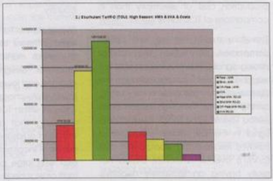


Fig. 9: Ekurhuleni TOU tariff: high season.

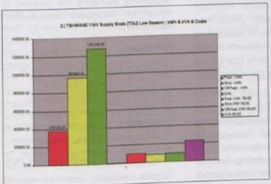


Fig. 10: Tshwane 11 kV supply TOU tariff: low season.

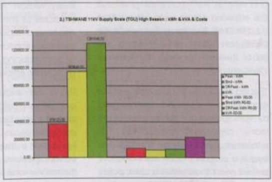


Fig. 11: Tshwane 11 kV supply TOU tariff: high season.

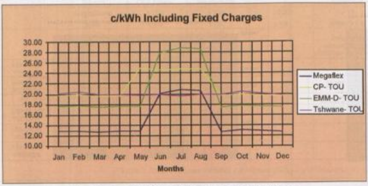


Fig. 12: Impact of different TOU tariffs on a specific customer.

Some tariff structures are energy unit based (c/kWh basis and are thus not time based), whereas the cost of producing electricity is based on hourly and seasonal TOU tariff structures. Some customers in the industrial sector have already been converted to TOU tariffs. The opinion is held that, in order for the wholesale pricing to be cost reflective, it should be TOU based.

However comparisons of a TOU based tariff can always be compared with an energy unit based tariff c/kWh. The point is that the industrial sector is probably more concerned about the per unit production cost of electricity than in comparisons of TOU tariffs.

Therefore should the per unit c/kWh comparison not reflect the correct pricing signals, they would probably not respond to it. For example, although the Ekuthuleni TOU tariff gives a very strong pricing signal in their high season peak period (c/kWh), the much lower pricing signal in the low season peak period (c/kWh) results in the energy unit cost (c/kWh) over a 12-months period not really having an extremely negative impact for the average high load factor industrial consumer.

The following clause is an extract from the EDI Draft Regulatory Framework for Distribution Industry of South Africa, July 2004, Revision 3: Draft for External Consultation:

"Pricing and Tariffs: Harmonisation of the many different structures currently used by municipalities and Eskom is one of the many challenges facing the EDI restructuring programme. The NER has begun a process of tariff rationalisation, but will need to establish a clear policy on the objectives of tariff harmonisation, including the method and timeframes that are anticipated."

Conclusion

Electricity tariff structural difference currently exist in various municipalities.

The TOU costing principle will be of utmost importance to minimize the peak demand and system usage.

Future tariffs charged to customers should be cost-reflective, including geographical differentiation resulting from the relative location of the loads from electricity generation plants, as well as the physical layout of the country.

Pricing signals for different load factors signal different messages to customers at various municipalities due to tariff structural designs e.g. higher kVA charges and lower kWh charges, versus lower kVA charges and higher kWh charges within TOU tariffs. It is therefore necessary that a national framework with strict guidelines be implemented to get rid of incorrect perception that may exist with large power users regarding tariff cross subsidies that are needed.

While consumers of electricity have every reason to question the tariff structures of monopolistic utilities, they also have a responsibility to analyse their own consumption patterns with a view to both reducing electricity cost as well as increase efficient usage of electricity.

Today no excuse should exist for any person involved in metering of customer electricity consumption using programmes in which accuracy is suspect. It is therefore the duty of all persons involved in metering, both to themselves and to their customers, to ensure accuracy. Honesty of intention requires that suppliers shall do more than merely believe that their "scales" are correct. It is their unquestionable duty to their customers to know that they are correct.

Unfortunately, it is a fact that metering knowledge, as taught in universities and technikons, or learned by way of in house experience, has a limited life due to the ongoing develop-ments in new metering technologies. In view of this, all people involved in metering or billing of electricity, especially complex metering and tariffs, must continually update their knowledge of developments.

Although spreadsheet applications may not be the ultimate tool to check and verify vast amounts of consumers' profile data obtained from meters, its application as an effective "check tool" to verify consumer accounts and consumption patterns should not be underestimated.

Due to the fact that all data is openly and transparently available in a spreadsheet, its real value lies in the fact that it may be utilized as a training tool to assist personnel and customers to understand the basic principles of tariffs and electricity (peak, standard, off-peak, kVA, kW, kWh, kvarh, kVAh, excess of 30% reactive energy, 0,96 PF, power factor, power factor correction, profiles, maximum demand, etc.).

Lastly, although not the least, where profile data is available, the SMS (super metering spreadsheet) may be very effectively used as a budget tool to model the impact of new tariffs on a customer's annual electricity bill.

The content, discussions, comments or views included in this paper do not necessarily represent the position or views of Ekurhuleni Metropolitan Municipality.

References:

(1) Elektron, journal of the Institute of Electrical Engineers, March 1997

(2) NRS 057-1:2001: Electricity metering

(3) NRS 034-0:2001: Electricity distribution - Guidelines for the provision of electrical distribution networks in residential areas.

(4) EDI draft Regulatory Framework for Distribution Industry of South Africa, July 2004, Revision3, draft for external consultation. Δ

Wholesale electricity pricing - a progress report

by Corrie Visagie, Eskom, and Naresh Singh, National Electricity Regulator

Eskom developed a wholesale electricity pricing system (WEPS), in conjunction with the National Electricity Regulator (NER). Access to WEPS will be available to key industrial customers (KICs), municipalities as well as to future Regional Electricity Distributors (REDs) as from 1st January 2005. The NER will periodically revise and announce the qualification criteria for WEPS.

WEPS is designed as a cost-reflective tariff to recover the cost of energy (generation), network services (transmission) and other costs necessary to deliver a wholesale electricity service. This will include costs for losses and wheeling through the distribution system. These costs will be unbundled to show the customer exactly what is paid for. Provision is made for levies and taxes that support socio-economic programmes. The implementation of WEPS is driven by the need to put the necessary arrangements in place for the bulk purchasing of electricity by qualifying municipalities and large customers prior to the establishment of a wholesale electricity market. According to government's strategy on the reform of the Electricity Distribution Industry (EDI), revised arrangements for the purchase of bulk electricity by municipalities and Eskom distribution is not dependent on the establishment of the REDs. WEPS will therefore provide a non-discriminatory wholesale price at which Eskom Distribution, qualifying large customers and municipalities - as well as REDs when they are formed - can purchase their electricity. In this paper Eskom and the NER presents a progress report on the planned implementation of the Wholesale Electricity Pricing System (WEPS).

What is WEPS?

WEPS is designed as a cost-reflective tariff to recover the cost of energy (generation), network services (transmission) and other costs necessary to deliver a wholesale electricity service. This will include costs for losses applicable. These costs will be unbundled to show the customer exactly what services are paid for. Provision is also made for levies and taxes that support socio-economic programmes.

WEPS implementation phases

The implementation of WEPS is a complex process and to ensure good order in the industry during implementation and especially to reduce the risks to the various parties, a phased implementation approach has been adopted.

- Phase 1 - internal to Eskom
- Phase 2a - retail unbundling to Eskom qualifying customers
- Phase 2b - retail unbundling to municipal qualifying customers
- Phase 3 - wholesale contracting
- Phase 4 - electricity market overlapping of certain phases may be possible due to the need to have WEPS ready for the first RED by July next year. Phase 2b and phase 3 may therefore overlap.

WEPS - Phase 1

WEPS - Phase 1 was implemented internally within Eskom under the current Eskom structure applying the principles of transfer pricing between Eskom Divisions and thereafter proper wholesale contracting between Eskom Divisions.

To promote understanding of the paper, the following basic structure is recommended:

- An introductory section, clearly setting out the background to the paper
- Main body of the paper
- A conclusion summarising the findings of the paper
- References, appendices and acknowledgement of sources and persons who co-operated in the compilation of the paper

WEPS - Phase 2

Phase 2a - To qualifying Eskom connected customers (which includes municipalities).

Implementing WEPS - phase 2 will mean that the electricity bill of customers will be unbundled and the respective cost components of a customer's tariff would be made transparent. A charge will be levied to compensate for Eskom's loss of revenue due to converting from a standard tariff to the WEPS tariff. This is called the WEPS surcharge. The incentive for customers to participate in WEPS - Phase 2 is that they would be placed in a position whereby it would be possible to monitor and manage their contribution to subsidies as well as understanding the exact individual cost components and pricing signals of their electricity bills.

Phase 2b - To qualifying embedded municipal customers.

Municipal key industrial customers will be able to get a transparent retail bill based on the WEPS components as was done for Eskom customers during Phase 2a. The same principles will apply. The NER will be responsible for this process.

WEPS - Phase 3

WEPS - Phase 3 will have to be implemented before the creation of the first RED to enable the RED to procure its energy requirements. Eskom would be signing separate contracts for energy and wires due to different interfaces required, although it would most probably still be one company. The NER will develop additional appropriate qualifying criteria for this phase such as financial guarantees.

WEPS Phase 4

Qualifying WEPS customers, retailers and traders will become participants in the electricity market and will be bound by the market rules. However, WEPS customers who would not want to be exposed to the risks of the electricity market (volatile prices) could then purchase their electricity from a retailer, trader or through a broker of their choice.

WEPS Implementation

To ensure the smooth implementation of WEPS, the following initiatives will take place as from September 2004 to address implementation of WEPS Phase 2a:

Activity	D-date
NER board to decide on Eskom's 2005 price increase.	21 October 2004
Eskom to meet with the WEPS Special Task Team to share the rollout plan of WEPS Phase 2a taking into account the annual Eskom price increase.	26 October 2004
WEPS rates for 2005 to be decided upon by the NER.	3 December 2004
WEPS implementation of NER approved WEPS customers.	1 January 2005

The following additional steps will be taken to prepare for the roll-out of WEPS during the above period:

- A WEPS impact study will be conducted
- A WEPS quotation will be prepared for qualifying key industrial customers and municipalities that intend participating in WEPS
- Quotation will be accepted or rejected
- Enter into contract negotiations for those qualifying key industrial customers and municipalities accepting the quote
- Supplementary agreements will be finalised and signed
- The relevant customers will be registered on Eskom's billing system.

Communication with the qualifying key industrial customers and municipalities is critical. To facilitate this, a detailed communication package will be developed that will be used as a communication tool by all Eskom customer executives. The Eskom customer executives will be briefed and the package and its contents will be presented to them to ensure that they are fully equipped. The communication package will be updated with the approved WEPS rates.

Conclusion

WEPS is a fully unbundled pricing system which splits wires and energy components clearly and giving customers detailed information on all the cost components, including levies and taxes. From Phase 3 onwards, customers will be required to contract separately for the unbundled services, either by creating an in-house capability or by contracting this service out. Customers converting to WEPS will initially only save to the extent that beneficial load shifting can be achieved. However, the savings could increase gradually as the NER considers the phasing out of the WEPS surcharge. Customers should also be aware that WEPS may still be further refined. It is therefore inevitable that NER-approved changes will be made to WEPS principles, structure and rates, from time to time. The most significant changes can be expected when the WEPS energy tariff is superceded by market prices in terms of the multi-market model that is currently under consideration by government. It should be noted that this document is not a comprehensive treatment of WEPS. Eskom's key customer executives can be asked for details on specific WEPS policy and more clarity on implementation issues. The NER website also contains additional information.

References

(1) NER website

(2) Minutes of WEPS meetings between Eskom and the NER Δ

The NER's web-based reporting system for licensees

by Caesar Vundule, NER Information Resources Management

The National Electricity Regulator of South Africa (NER) is the regulatory authority over the Electricity Supply Industry (ESI) in South Africa. It is a statutory body, established in terms of the Electricity Act, No. 41 of 1987, as amended by the Electricity Amendment Acts of 1994 and 1995.

The role of the NER is to regulate the ESI by ensuring that the most efficient and effective ESI is in place to meet the requirements of existing and future electricity customers.

Activities of the NER include:

- Issuing licenses for the generation, transmission and distribution of electricity
- Determining the price at which licensees sell electricity and (in the case of Eskom) the rate of return allowable
- Regulating tariffs of licensees, to prevent undue discrimination between customers
- Regulating quality of supply and service standards
- Performing inspections of the equipment of licensees
- Regulating to protect low-income customers by keeping tariffs affordable
- Settling disputes between licensees and customers, and between different licensees themselves, regarding the right to supply electricity
- Collecting necessary information from electricity undertakers or consumers
- Advising the Minister on any matter relating to the electricity supply industry

Objective of the paper

The objective of this paper is to provide an overview of the new NER reporting system for licensees.

Information and the regulator

Relevant, accurate, reliable and timely information plays a key role in the NER's regulatory function, including planning and decision-making. However, collecting data and information has resource implications, both for the regulator and the licensees.

NER reporting system project

Rationale for the project

The NER collects information from licensed electricity generators and distributors, mainly annually through the use of forms (G-forms and D-forms respectively) that were designed in the 1990s. The G-forms are used to collect generation data from electricity generators, and D-forms (D1 - D8) are used to collect data related to the distribution of electricity from electricity distributors. The data is collected at the end of the financial year of the municipalities and Eskom respectively, and submitted manually to the NER. While T-forms exist for collection of data and information from Eskom Transmission, these forms are presently not being used. All the forms are captured manually into the NER's databases. The quality (completeness, accuracy and timeliness) of the information is generally poor.

The NER recognises that there are a number of problems with the current processes and procedures for collecting data and information from licensees. Such problems include:

- Too much information required by the NER
- Incomplete forms sent to the NER
- Poor response rate by licensees
- Incorrect data submitted
- Lack of capacity in some licensees to comply to the reporting requirements
- Refusal to report some information by licensees
- Manual submission of information, which is inefficient, and has the potential of introducing errors at several stages

The objective of this project was to develop a robust reporting system for the NER's interaction with licensees. The guiding principle was to develop a system that would collect relevant information that would assist both the NER and licensees to better manage their business.

The development of the new reporting system

The new system was developed by conducting the following:

- A review of the existing reporting systems, identification of gaps, and making preliminary recommendations for improvement
- Development of a specification of information needed according to the current and known future regulatory system in South Africa
- Preparation of draft data reporting schedules, manuals and procedures (manual and electronic) through the involvement of the relevant departments within the NER
- Pilot testing of the web-based reporting system and the draft reporting schedules at Tshwane, City Power and Eskom, and modification of the reporting system based on the feedback that was obtained. In addition there was interaction with Nokeng Tsa Taemane to understand their concerns regarding the present reporting system
- Finalising the reporting schedules, manuals and procedures. The operating and reporting manual (ORM) should be user-friendly and complete with a dictionary of the data elements in the reporting schedules to ensure a common understanding. The reporting schedules should have reporting dates and deadlines that specifically coincide with and facilitate the budgeting cycle of licensees
- Finalising the computerised system to capture, validate, analyse and report information based on the new reporting schedules

An industry reference group consisting of representatives from the AMEU, Eskom, EDI Holdings and the NER was established. The role of the reference group was to give guidance to the project team during the development of the reporting system.

NORAD funded this project through the co-operation agreement between the NER and the NVE of Norway (The Norwegian Water Resources and Energy Directorate).

Description of the new NER reporting system for licences

The new reporting system is a web-based set of centrally stored and maintained documents (reference documents and input formats) that are accessed over the Internet. The system will allow licensees to access the NER via the Internet, and directly capture their information into the NER's databases. During the initial stages of implementation, provision will be made for using alternative (off-line and manual) methods for reporting data until all licensees can fully utilise the web-based system.

Fig. 1 shows the structure and processes involved in web-based reporting solution. The system contains two main parts:

- User interfaces comprising
  "How to" manuals
  Mapping instructions
  Web based input formats

- Central storage comprising:
  An internet mapping interface
  The NER database
  A report writer

The input formats will feed the NER's central database through a web-server. The technical and financial reporting system will consist of documents and software applications that are specifically designed for:

- Structuring and capturing of all data required by the NER presently for licensing purposes for electricity distribution, transmission and generation and other licensed activities; and
- Structuring and capturing of data to accommodate future requirements expected to become the responsibility of the NER.

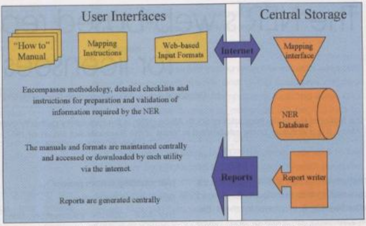


Fig. 1: Solution overview of proposed new NER utility reporting system.

A web-based data capture concept offers the distinct advantages of:

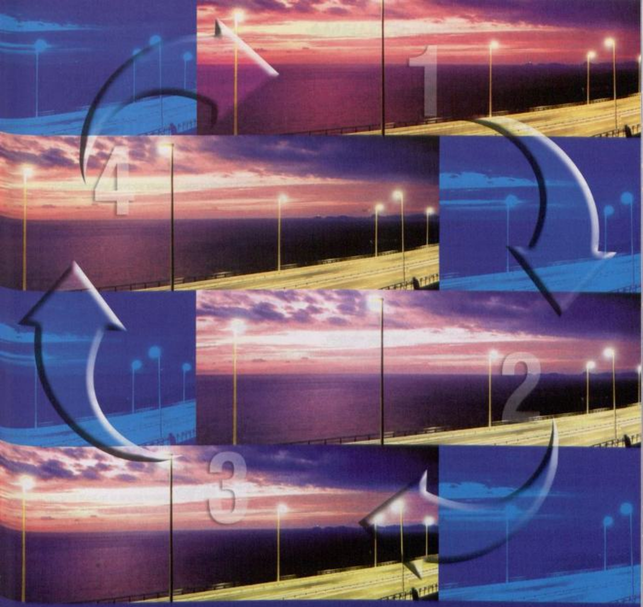
- Easy access to the most current version of forms and documents from anywhere in the country via the internet
- Easy maintenance and updating of documents and forms in one central server without the cost, time delay and risk involved in having to disseminate software updates to a large number of users (and assisting many of them in the upgrade procedure)
- Enabling the NER to monitor the progress of data capture from individual utilities online, i.e. the NER could obtain daily updates on what was captured and who captured the data
- Automatically generated e-mail reminders to users regarding deadlines; and all data being stored in one secure location and being immediately accessible to the NER for report generation
- Enabling licensees to access their own reports. The plan is to also have reports that compare similar licensees that can be viewed by the licensees

Roll-out and implementation of the new reporting system

To kick-start the roll-out, a presentation on the new reporting system was made to the AMEU's 20th technical meeting in Richards Bay in October 2004. During October/November 2004, six stakeholder workshops shall be held. Thereafter, it is anticipated that all licensees will be visited to demonstrate the new reporting system and to ensure that licensees can access the NER databases and work through the reporting system. This process is scheduled for October/November 2004 to March 2005.

Conclusion

The new web-based reporting system has been developed in order to address most of the problems that have been experienced so far. Licensees will be required to report their 2004 or 2004/5 financial year data using the new system. The new reporting system can only be truly beneficial to the NER and licensees if there is buy-in and collaboration from both parties. Δ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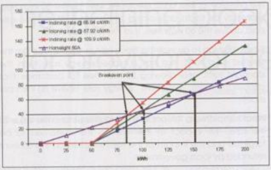


Fig. 2: Different tariffs compared to the standard tariff.

Fig. 2 shows examples of different rates compared to the standard tariff, and their respective breakeven points.

Tariff too high	Tariff too low	Optimal tariff
Many customers will see no benefits	Many customers will benefit	The optimal number of customers will benefit
Customers will not convert	Many customers will convert	The customers targeted will convert
Not appropriate targeting - deserving customers will receive no benefit	Not appropriate targeting - will allow for unintended customers to benefit.	Appropriate targeting
Limits the benefits of providing electricity and the reason to provide free basic services.	Has the potential to encourage wastage	Has DSM potential
Potential for over-recovery	Potential for revenue loss	Benefits or losses kept to a minimum

Table 2: Features of the breakeven point in the context of providing free basic electricity.

Determination of the rate to be used

Table 2 gives a high level summary of what pricing signals will be created at different rates and their different breakeven points.

The challenge is to determine the "optimal" breakeven consumption. This may not be as simple as first appears. For example, Eskom has national tariffs, but in different areas of South Africa the average consumption varies. What might be suitable in one area may be inappropriate in another area.

The challenge is to determine the "optimal" breakeven consumption. This may not be as simple as first appears. For example, Eskom has national tariffs, but in different areas of South Africa the average consumption varies. What might be suitable in one area may be inappropriate in another area.

There is, however, a guideline that has already been set with regard to the breakeven point, namely 150 kWh. This consumption will be the value used to determine the rate above the knee-point.

The tariff is shown in Table 3.

It must be noted that here is no breakeven between Eskom's standard tariffs and the current targeting mechanism as the rate is the same - the only difference being the free 50 kWh per month.

The inclining block rate above the knee-point, in this case is not cost-based, but rather is compared to the existing tariff to ensure that the correct pricing signals are provided so that customers receive the optimal benefit, the revenue risk is minimised and that subsidies are not increased.

There are therefore two factors that will influence the decision of the rate value. These are:

- The revenue impact.
- The targeting effectiveness i.e. achieving the maximum benefit to the optimal number of customers.

Calculation of the revenue impact

Unless all costs are recovered, there is a revenue impact caused by the implementation of free basic electricity. The size of this "revenue foregone" is reliant on the targeting mechanism chosen and the amount allowed to be claimed.

The revenue foregone (on an average c/kWh basis) is the difference between what would have been received on the tariff excluding the free basic electricity allocation and the national average allocation* allowed by government to be claimed. The shortfall must be funded through other mechanisms such as from the shareholder. For the purposes of this paper, only the revenue foregone as described above is used in determining the revenue impact and even though they are relevant, implementation and other costs are ignored.

Revenue impact at the standard tariff

The current amount allowed to be claimed by Eskom from local authorities is 35.36 c/kWh. This rate is determined by the NER on an annual basis.

The amount claimed from local government is as follows:

No of customers x 50 kWh x T_{FBE}

where T_{FBE} = National average claim tariff

The following simple formula is used to calculate the revenue foregone.

No of customers x 50 kWh x (T_{STD}# - T_{FBE})

where #T_{STD} = Standard tariff

If in the event the standard tariff is less than the national average claim tariff, then only the standard tariff is claimed i.e. there is no revenue foregone as the full amount can be claimed.

Revenue impact for FBE inclining block rate tariff

It is, however, not as simple to calculate the revenue foregone using an inclining block rate tariff. While for a single energy rate tariff the average c/kWh remains constant irrespective of the usage, for an inclining block rate tariff above the knee-point, the average c/kWh changes as consumption increases. This is demonstrated in Fig. 3.

Tariff	Standard	Inclining block rate with first 50 kWh @ 0 c/kWh
Homelight 2.5 and 20 A	39.08 c/kWh	58.62 c/kWh
Homelight 60 A	43.96 c/kWh	65.94 c/kWh

Table 3: Standard tariff and FBE inclining block rate.

* *As Eskom and local authorities have different tariffs structures and rates, a decision was made to ensure equity, that Eskom on a national basis will only be allowed to claim from local government up to this "national average" rate as determined by the NER from time to time.*

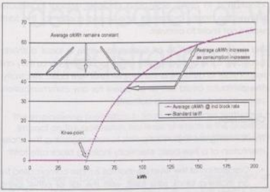


Fig. 3: Average c/kWh at different consumption levels.

The current revenue impact looks only at the national average claim rate and the amount of kWh provided for free. There are a number of different methods of determining the revenue foregone and the amount to be claimed, with differing revenue impacts. There are now three tariffs relevant in determining this impact.

- The revenue that would have been received on the standard tariff
- The revenue received by the customer on the FBE inclining block rate tariff
- The national average claim rate for 50 kWh

The benchmark for evaluating the revenue impact of any new methods is the current method of determining the revenue impact i.e. there should be no significant difference in revenue or the amount claimed between methods either negative or positive. Fig. 4 shows the current method.

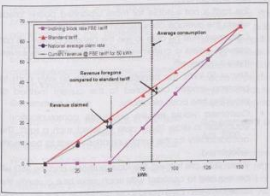


Fig. 4: Revenue received on current method.

The revenue foregone on the current method remains constant after 50 kWh on a R/customer basis. The challenge is to determine how this will be done with an inclining block rate tariff.

Three different methods are evaluated.

Method 1

As mentioned the average c/kWh is relevant for the inclining block rate at it changes at different consumption levels. Fig. 5 shows:

- If the first 50 kWh is claimed at the national average claim rate, there is a potential for over-recovery at a lower point than the average consumption (point A on the graph).

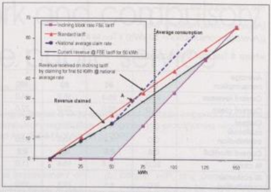


Fig. 5: Revenue received using the national average claim rate for 50 kWh.

- There is, however, limited difference between the impact on the revenue foregone using this approach and the current method.
- It is also unlikely that consumption levels will be significantly higher than the breakeven at point A. If consumption levels do increase, a review of the average rate would be appropriate.

As the amount of revenue below the breakeven point is always less than the current revenue (shown by the shaded area), it means that unless an appropriate method is devised, either the revenue foregone must increased or the revenue claimed from local government must increase. The above method avoids having to do this.

Method 2

Taking the average consumption into account, the following formula can be used to determine the revenue impact:

(Average consumption x T_{FBE}) - ((Average consumption - 50 kWh) x $T_{Incl\ BR}$#)

where #$T_{Incl\ BR}$ = Inclining Block rate above 50 kWh rate.

To illustrate the potential impact at different average consumption levels are given in Table 4.

Average consumption	50	60	80	100
Current revenue	22.0	26.4	35.2	44.0
Current claim	17.7	17.7	17.7	17.7
Current customer contribution	0.0	4.4	13.2	22.0
Current shortfall	**4.3**	**4.3**	**4.3**	**4.3**
IB claim	17.7	14.6	8.5	2.4
IB customer contribution	0.0	6.6	19.8	33.0
IB shortfall	**4.3**	**5.2**	**6.9**	**8.6**

Table 4: Customer revenue impact at different consumption levels. IB = Inclining block rate.

It can be noted that the revenue impact per customer is more negative using the above formula, than the current shortfall.

Method 3

Another alternative would be to do away with the national average claim rate, and let the claim be made against the standard tariff rate. If this were allowed, it would mean an increase in the amount required from local government, because the standard tariff is higher than the national average claim rate.

The formula to be used is:

(Average consumption x T_{STD}) -
((Average consumption - 50 kWh) x $T_{Incl\ BR}$ #)

where # $T_{STD\ BR}$ = The standard tariff rate

Average consumption	50	60	80	100
Current revenue	22,0	26,4	35,2	44,0
Current claim	22,0	22,0	22,0	22,0
Current customer contribution	0,0	4,4	13,2	22,0
Current shortfall	**0,0**	**0,0**	**0,0**	**0,0**
IB claim	22,0	19,8	15,4	11,0
IB customer contribution	0,0	6,6	19,8	33,0
IB shortfall	**0,0**	**0,0**	**0,0**	**0,0**

Table 5: Customer revenue impact using the actual tariff.
IB = Inclining block rate.

The revenue shortfall reduces for the distributor, but the amount claimed from government is higher.

Targeting effectiveness

The current average consumption is important in assessing the revenue risk and the potential number of customers that could convert to the tariff.

Average monthly consumption can differ significantly throughout South Africa. In the Gauteng area the average consumption in Eskom is about 125 kWh per month, while in the poorer Eastern Cape region, the average consumption is below 50 kWh per month.

If the breakeven is set at the average of between 80 and 90 kWh per month, basically most customers in the Eastern Cape region would benefit on the inclining block rate tariff, while in the Gauteng region only a minority of customers use below the breakeven and would select the tariff.

However, this tariff may be one of a suite of targeting mechanisms used i.e. and other targeting mechanisms may be more appropriate i.e. in the Eastern Cape a more appropriate mechanism would be supply size limited tariff, instead of the FBE inclining block rate. This does not negate the fact that a tariff based a certain consumption level, will not necessarily be suitable in all areas within a distributor's supply area.

For example, if the breakeven is set at 150 kWh per month, most of Eskom's Homelight customers would benefit from this tariff. This is clearly not sustainable as it is almost a broad based approach and funding from government may not be adequate to supply all these customers. This needs to be balanced against the fact that this tariff would not be suitable for more urbanised poorer areas where the average consumption is much higher.

Another important factor is how to convert customers to the tariff. This could be done on application or through automatic conversions (through the billing/vending system). Automatic conversions, while possible, are more complicated with prepayment metered customers - especially where data is not correct or the system in not an online system. For conventionally metered supplies, automatic conversions are usually quite simple to do.

Where an automatic conversion cannot be done, it is important that customers are provided with enough information to make educated choices. Without adequate knowledge, many customers who would qualify for the tariff would not know to convert.

This communication to all customers within a local authority boundary is the accountability of the local authority as they are responsible to determine the recipients of free basic electricity. The distributor could act as an agent for any communication, as contacted by the local authority.

Conclusion

The following are important points to note regarding the implementation of a free basic electricity inclining block rate tariff:

- Calculation of the revenue shortfall is more complicated for an inclining block rate tariff, with the risk of either losing revenue or having a windfall benefit, depending on the method chosen to claim against using the national average tariff rate.
- The choice of claiming method would depend on the availability of funding.
- If the breakeven is set at 150 kWh which is the level of consumption as recommended by the DME as one of the targeting methods this could be effectively a broad-based approach in many areas of the country. The risk on the revenue foregone is may be higher depending on the method of claiming and the amount of customers targeted could increase i.e. increasing the impact of funding requirement from government.
- The targeting approach must be practical currently on a national basis and in future on a regional basis.
- A 20 A and a 60 A inclining block rate tariff would have to be developed, to be in line with the suite of supply options and to ensure that the breakeven between the standard comparative tariff and the inclining block rate tariff is kept at the target level.
- This tariff is not suitable for more urbanised poorer areas where the average consumption is much higher.
- Customers must be able to see the benefits or they will not convert. Unless a customer uses less than the breakeven there is no benefit.
- Above 50 kWh, the benefit of receiving 50 kWh starts to become eroded compared to the current method of providing free basic electricity.
- Customers would require adequate communication / education in order to be able to select such a tariff. The accountability for this communication needs to be clearly established.
- When REDs are formed, the local authority and the RED will be required to contract with each other as is currently the case between Eskom and local authorities. One RED could be required to contract for different free basic electricity options as required by each individual local authority. This has the potential to be administratively cumbersome, especially with regard to the flow of subsidies.

In conclusion, this tariff could be used as the first national tariff throughout South Africa (for both Eskom and municipal customers). This would facilitate the provision of free basic electricity and provide the first step in rationalising residential tariffs. In order to implement this national tariff, the development and approval at all levels would have to be directed by the NER and the revenue impact would have to be approved by the relevant government departments. Δ

Identification of work and compulsory registration in the public service

by Paul Roux, ECSA

The engineering profession in South Africa faces numerous challenges across a wide spectrum of critically important issues that impact on the profession, not least of which is the question of compulsory registration of engineering practitioners required in terms of the Engineering Profession Act, 2000 (Act No 46 of 2000).

The Engineering Council of South Africa (ECSA) finds itself part of the "Magnificent Seven", (a phrase coined by the Council of Provinces), which is the all-time highest number of acts ever passed by parliament in one sitting. These acts were passed by parliament in November 2000.

ECSA's act came into operation on 26 January 2001 by Proclamation by the State President. The date on which the Act became effective was 28 August 2001, when the new Engineering Council of South Africa had its first meeting.

With the exception of the Council for the Built Environment (CBE) all other Acts are substantially similar, and the powers given to the respective Councils are almost identical.

The CBE has an overarching responsibility and was established to provide leadership to, and ensure good governance of the professions, while serving as a two-way channel for coordinated input, into the restructuring and development process, between the professions and Government.

Government policy

A Forum for the Professions in the Built Environment, established in 1994 by minister Radebe (then Minister of Public Works) produced a "policy document on the statutory regulation of the built environment professions", that among many other policy issues, stated the following:

"Professional expertise in the country is a national asset and should be managed as a scarce resource of high value. This expertise is a resource that is renewable but that is also subject to degradation if standards are allowed to decline and/or interest in entering the professions as a career is not promoted. The intrinsic value of professions lies in their essential role and function in socio-economic development. While socio-economic development and the improvement of the quality of life in South Africa enjoys priority attention, professional expertise needs to be nurtured, professional standards need to be maintained and professional services need to be within reach of all communities..." and

"It is the opinion of the ministry that, in order to meet the objective of upholding standards through registration, all persons who are eligible for registration and who practice their vocation, whether self employed or salaried, should be obliged to register. Legislation will make provision for certain professional titles to be reserved for registered persons. This will enable the general public to identify the competency levels of the registered persons."

In this context it is clear that the government has a strong political will to ensure public interests, which is strongly supported by the notion that a strong profession which maintains high standards of competence is an effective means of promoting public interests. This objective was to be achieved through a process of compulsory registration.

Government's policy manifested in CBE Act, 2000

The government's policy regarding compulsory registration is manifested in the provisions of the Council for the Built Environment Act, 2000 (Act 43 of 2000) which is quoted below:

Section 20: Identification of work

"20.(1) The council must, after receipt of the recommendations of the councils for the professions submitted to it in terms of the professions' Acts, and before liaising with the Competition Commission in terms of section 4(q)

(a) determine policy with regard to the identification of work for the different categories of registered persons;

(b) consult with any person, body or industry that may be affected by the identification of work in terms of this section.

(c) The council must, after consultation with the Competition Commission, and in consultation with the councils for the professions, identify the scope of work for every category of registered persons."

Government's policy manifested in Engineering Profession Act

As in the previous case, the government's policy is also manifested in similarly worded provisions of the other Built Environment Councils' Acts, an example of which (pertaining to engineering) is referred to below:

Engineering Profession Act, 2000

General powers of ECSA - Section 14

- Take steps necessary for protection of public in dealing with registered persons, maintain integrity and enhance status
- Take steps necessary to improve standards and services

Compulsory registration

- Section 18(2) - "A person may not practise in any of the categories ... in subsection (1) unless ... registered in that category".
- Section 26(2) - "A person who is not registered ... may not perform any kind of work identified for any category of engineering."

Probably the most important function that ECSA has is to protect (promote) the health, safety and interests of the public in their dealings with registered persons. While ECSA has been obligated to fulfill many functions in terms of the Act these functions are almost without excep-tion aimed at achieving the main objective, i.e. setting professional standards of education, professional development and conduct, accredi-tation etc.

The only way in which these objectives can be reasonably achieved in a structured way is to have a system where all practitioners are subjected to the same levels of competence and professional conduct, i.e. all must be registered.

The sections in the above Act are aimed at achieving compulsory registration.

A very important provision in the Act is Section 44 which compels the State to conform to the provisions of the Act as well. This includes not only Central Government, but also Provincial and Local Government. It is in the area of Local Government that organisations such as the AMEU and IMESA can and should play a vital role in assisting ECSA to identify engineering work in local government that must be reserved for registered persons.

ECSA'S area of jurisdiction has many facets

On the one axis, ECSA's area of influence spans the nine main disciplines of engineering in which the engineering professionals practice. These main disciplines obviously include all sub-disciplines and hybrid-disciplines:

- Aeronautical engineering
- Agricultural engineering
- Chemical engineering
- Civil engineering
- Electrical/electronic engineering
- Industrial engineering
- Mechanical engineering
- Metallurgical engineering
- Mining engineering

On the other axis, ECSA's area of influence spans some 15 economic sectors (using the SETA demarcations), in which engineering professionals practise their particular disciplines:

- CETA: Construction (MoU)
- CHIETA: Chemical industries (MoU)
- DIDTETA: Diplomacy, intelligence, defense, trade & industry
- ESETA: Energy (MoU pending)
- ETDPSETA: Education, training & development practices
- FIETA: Forest industries
- FOODBEV: Food & beverages manufacturing
- HW SETA: Health & welfare
- ISETT: Information systems, electronics & telecom. technology
- LGWSETA: Local government, water & related services
- MERSETA: Manufacturing, engineering & related services
- MQA: Mining qualifications authority (MoU)
- PAETA: Primary agriculture
- SETASA: Secondary agriculture
- TETA: Transport (MoU)

ECSA is in the process of negotiating and signing "memoranda of understanding" with these SETAs, in an attempt to optimise the provision of training (professional development) and to achieve a high level of cohesion between provision, quality assurance in the workplace and the registration requirements of the profession. It is especially necessary that cooperation between ECSA and the various SETAs be optimised considering that engineering professionals will be compelled to register in future, i.e. licensed to practice, and that they should be trained well enough to qualify for registration.

This co-operation means that ECSA's "commitment and undertaking" system should be integrated into learnerships which would incentivise employers to register candidates in learnerships.

Other legislation influencing identification of engineering work

When identifying engineering work, ECSA has to be sensitive to various other acts of parliament which have an impact on the identification process. The potential impact that the above cited acts have are as follows:

- Constitution: A balance must be maintained between a person's constitutional right not to be discriminated against, or the right to free economic activity. Identification of work will no doubt preclude non-registered persons from performing the work, which can be seen as discrimination and limiting his/her right to free economic activity. Here the general interest of the public must be weighed up against that of the individual.
- In addition to the constitution, the identification must also be justified in terms of the principles of free enterprise.
- The Occupational Health and Safety Act already provides for a system of licensing of engineering practitioners, and some form of synergy between the acts must be achieved.
- The above principles also apply in respect of the Mine Health and Safety Act.
- While the National Building Regulations Amendment Act of 1995 already provides for registered persons to operate as "competent persons" much thought needs to be given to optimising synergy between the acts.
- The Water Act provides for the "registration" of engineers on large dams, under the auspices of the Department of Water Affairs. Duplication must be minimised if not avoided.
- There may be many more examples of overlap.

Interesting challenges facing process and approach to identification of work

Two approaches will likely be followed by ECSA in addressing identification of work:

- Inclusive approach: Define engineering work in generic terms (as a vocation distinct from architecture, fashion design, law etc.) and then permit all registered persons to perform such work on condition that they should limit the extent of their work only to that which they can perform competently having regard to their education, training and experience.
- Define specific kinds of engineering work that justifies, in terms of competency requirements, reservation exclusively for persons who are specifically licensed to perform such work i.e. dam engineering, structural design, lift inspection, consulting engineering etc. This approach would be analogous to specialist registration in the medical profession.

Once the engineering work has been identified, suitably defined and prescribed, registration will automatically become the "license to practice", either as a "generalist" or as a "specified category".

The process so far and next steps

ECSA has already appointed a "project co-ordinator" to drive the development of the project.

The immediate next step is to appoint a steering committee consisting of highly experienced and distinguished individuals who are renowned for their ability to think laterally and at a high strategic level. These individuals will probably represent the nine main disciplines of engineering, but they will need to have a very good knowledge of how the discipline is practiced in various sectors of the economy.

It will be the function of this group of individuals to draw up a framework capable of accommodating specific types of work in the engineering disciplines, as practiced in various economic sectors.

Other important steps in the process

Wide consultation must take place with stakeholders - to ensure reasonable buy-in. Much progress has already been made in the Mining and Minerals Sector. The Mining Qualifications Authority (MQA) has been actively working over the past year to assist ECSA in identifying work in this sector that must be performed by registered persons.

The next sectors requiring immediate focus are the civil and construction sectors, which will be followed by the energy and chemical sectors. At the same time ECSA is engaging with the government (DoW) to ensure equal application of the government's policy on compulsory registration among all departments at central government level. The DoW's assistance will also be sought regarding consistent application of the policy at provincial and local government levels.

As far as the SETAs can assist with this process, they will be regarded as stakeholders.

The final stages of this process will be for ECSA to recommend the identified work to the Council for the Built Environment, who will be required to do the necessary consultation with the appropriate stakeholders at this level. The CBE will also be responsible for negotiating the identified work with the Competition Commission.

Once the process of consultation is concluded the CBE will recommend to the minister that the identified work be published in the Govern-ment Gazette, whereafter persons affected by this will be compelled to be registered.

Continuing professional development (CPD)

To remain globally competitive and to maintain the high standard of engineering for which the South African engineering profession has become known in the past, it is necessary for engineering practitioners in our country to maintain their engineering knowledge and skills, like their overseas counterparts, in a more formally structured way than before. Section 22 (1) of the new Engineering Profession Act, 2000 (Act 46 of 2000) requires that a registered person has to renew his or her registration and has "to apply, in the prescribed manner, to the Council for the renewal of his or her registration".

In today's rapidly changing technological world it is no longer possible to rely on basic engineering studies and a few years of practical training to provide professional advice and services. One needs to update one's knowledge regularly, and develop and refine one's skills. This means undertaking on-going or continuing professional development. Since CPD is generally recognised internationally as a world-best practice, ECSA's commitment towards international agreements, like the Washington Accord, Sydney Accord, Dublin Accord and agreements for international mobility of engineering practitioners, also compels ECSA to ensure that engineering practitioners maintain their personal CPD at a satisfactory level.

One of the prerequisites for signing any mutual recognition agreements with individual professional societies abroad is that persons wishing to avail themselves of the agreement must show evidence of CPD. Without this requirement, ECSA would not be able to enter into any agreements with its foreign counterparts.

Where CPD takes place:

(Details are provisional and still under consideration)

Category 1: Planned formal interventions

These activities are educational, institutional and research-based conferences, large-group workshops, lectures, seminars and refresher courses provided by recognised, learned engineering societies and tertiary institutions. These activities may be organised on a regional, national or international basis and are non-recurring.

Category 2: Workplace activities, excercising responsibility and taking on new challenges

Work-based activities such as work-based learning, transfers to new departments, technical work in a practitioner's field of specialisation will be given credit. As activities in this category are related to a practitioner's day-to-day work, a lower credit weighting is given to these activities. Recognition is given to these activities based on the notion that practitioners have to remain current to perform their day-to-day engineering responsibilities. Credit will also be given to persons mentoring subordinates.

Category 3: Individual activities

- *Professional activities:* These activities will include external examiner, review of technical papers, participation in technical (non-institution and institution committees or task groups) as well as taking part in statutory, professional or non-technical committees.
- *Examinations, evaluations and assessments:* of applications for professional registration on behalf of ECSA. Examinations are restricted to final year undergraduate and all post graduate oral examinations, as well as evaluations of qualifications as member of ECSA's Qualification Evaluation Committee and the evaluation of dissertations/theses.
- *Self-study:* These activities include, but are not restricted to studying of journals, as well as electronic or computerised material, for which an approved method of assessment is in place. All activities under this item must be verifiable. Membership of a recognised learned society may assist practitioners to have these activities verified.
- *Research and publication:* In peer reviewed journals/chapters in books. Principal author of peer-reviewed papers and co-authorship will be recognised as well as authorship of articles written for CPD purposes, where original research is not involved.
- *Teaching and/or training activities:* by part-time lecturers to under-graduate students and lecturers to post graduate students.
- *Paper/poster presentation/lectures to peers:* Conference papers/posters in respect of Category 1 activities are recognised.
- *Supervision of candidates for higher degrees:* The activities may also include being the promoter, mentor or study leader for masters or doctoral qualifications.

Credits system

Category 1

Attendance of structured educational meetings will be credited with 1 credit per 10 notional hours of attendance. A maximum of 4 credits (i.e. 80%) may be accumulated under this category. Attendance of category 1 activities will be rated at 10 notional hours for a full day of attendance and 5 hours for a half day of attendance. Attendance of evening seminars will receive a maximum of 2 notional hours' credit, which means that the attendance of 5 such short seminars annually would be needed to receive 1 credit.

Category 2

A weighting of 1 credit for every 400 hours per year for engineering related work (including management) is awarded for this category. A maximum of 2 credits for 800 hours per year may be acquired in terms of this activity.

In addition, development and professional activities (mentoring candidate engineers, technologists and technicians) in the work place and career guidance within the working environment will be credited with a maximum of 1 credit for 50 hours of mentoring per year.

Category 3

- *Professional activities and examinations/evaluations/assessments*

  Examinations/evaluations/assessment of these will be credited with 1 credit for every 10 notional hours of active involvement.

  The evaluation of dissertations/theses by examiners will be credited with a maximum of 2 credits.

- *Research and publication*

  A principal author of peer-reviewed publication will receive 2 credits

  Co-authors will be credited with 1 credit per published paper.

  Authors of articles written for CPD purposes on request, where original research is not involved, will be awarded with 1 credit per article published.

- *Teaching and/or training activities*

  These will be credited with 1 credit for every 10 notional hours of lecturing.

- *Paper/poster presentation/lectures to peers.*

  In respect of Category 1 activities, papers e.g. conference papers/posters, will receive one credit.

- *Relevant additional qualifications (these are exceptional allocations)*

  A completed one-year diploma will receive 5 credits, and a completed two-year diploma or honours degree with 10 credits. A completed masters or doctoral degree will receive a maximum of 15 credits.

- *Supervision of candidate(s) for higher degrees*

  The activities will be credited with 2 credits per candidate per year and include being the promoter, mentor or study leader for masters or doctoral qualifications. Δ

Electrical accident safety briefings

eThekwini Electricity fatal accident

by Bobby Nell

This report was requested before end July 2004 for the AMEU Technical meeting in mid October 2004.

This matter is sub-judice as the Department of Labour have not conducted their investigation yet, and this report is only a brief outline of the incident.

The accident took place at approximately 11h55 on 22 January 2004 and involved three clearance assistants who work with a team, under the supervision of a ganger driver, to clear vegetation from the vicinity of power lines from 33 kV to 275 kV.

Our control section were notified via our laid down procedures of a "mayday" incident and ambulances were dispatched urgently but unfortunately one worker had passed away and the other two who were burnt were taken to the local hospital and have since made a recovery and returned to light duty.

On the day of the accident the ganger driver was instructed to clear vegetation under one of two parallel 33 kV lines, physically separated by approximately 10 m. These lines supply the Tongaat area that is supplied from an Eskom substation. The line requiring attention had been isolated for other work on that circuit. On arrival at site the driver parked on the pavement in close vicinity to the work area as the road is a narrow and busy thoroughfare, unfortunately under the live 33 kV line. The ground clearance satisfied the OHS Act requirements.

The aluminium ladder was taken off the top of the truck in the normal manner without incident by sliding it along the runners and then carried down a bank to the work site.

On completion of the job, the clearance assistants carried the ladder back to the truck, and it has been stated that the gang was told to break for lunch. The fact is that the three clearance assistants proceeded to load the ladder back on the truck immediately and, for some reason, the ladder was raised into the vertical position and broke close proximity, resulting in the flashover which killed one line hand and burnt two others.

Findings and recommendations

- The incident has been used to re-emphasise to all staff the need for vigilance and that a vehicle of this sort must not be parked under an overhead line in this type of circumstance.
- eThekwini Electricity are investigating the use of non-conducting ladders for the long extension ladders used by the HV Operations Department. (fibre glass ladders are used exclusively in the case of the shorter extension ladders associated with LV and 11 kV power line work, but aluminium ladders have been considered necessary for the conditions associated with the higher voltage power line work.)
- All staff not yet instructed how to load and unload ladders have received training for this procedure under all situations.
- eThekwini Electricity are negotiating with Eskom to have sensitive earth fault protection at the source substation supplying the Tongaat area.

Benoni CCC - 11 kV incident

by JJ Roos

An unfortunate incident occurred on 12 June 2004, at about 14h00 in Benoni when an artisan assistant, P. Makhetha, sustained very serious burns by inadvertently coming into contact with live 11 kV overhead lines whilst performing after-hour standby duties.

On instruction of the director of operations and maintenance, electricity and corporate, an investigation team led by the chief engineer (operations, electricity, corporate) investigated the incident.

On Friday 18 June 2004 at the investigation, the area manager of the Electricity Division, Benoni CCC, reported that staff from the Linmed Hospital informed him that there is a possibility that both hands of P. Makhetha may have to be amputated due to the extensive damages caused to his hands during the incident. It has since been established that both hands of Makhetha have been amputated between the wrists and the elbows.

Description of events

N. Motau received a complaint from the Eastern Regional Call Centre of a phase-out at Clyde Brickworks, North Road, Putfontein, Benoni.

An investigation by Motau and Makhetha showed that an 11 kV "jumper connector" at pole no. BB19/B69/4 North Road Putfontein, yellow phase, had burned off, where it was connected to a set of "cut-out" fuse links.

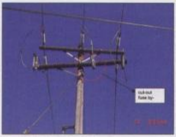


Fig. 1: "Cut- out" links were opened in order to repair a burned-off jumper conductor at Pole BB 19/B69-4 in North road, Putfontein Benoni.

Motau contacted the standby duty official, J. Swanepoel, to obtain permission to operate a set of "cut-out" fuse links at pole no. BB19/B69/1, the nearest point of isolation, in order to isolate the portion of overhead power lines where they were required to repair the said "jumper connection".

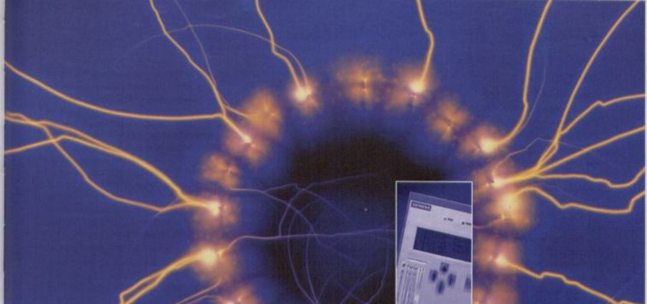
Permission was obtained from Swanepoel, after he had verified by means of a line diagram that by opening the fuse links at pole no. BB19/B69/1, they would safely isolate the overhead line where the repair work was to be carried out. Motau opened all three "cut-out" fuse links and proceeded to the point where the repair work was required.

At pole no. BB19/B69/4, Motau and Makhetha used a mobile elevating platform truck to rise to the top of the said pole, to test.

During the process of moving upwards, Makhetha, who was reported to be with Motau in the bucket of the mobile elevating platform truck, inadvertently came into contact with the live 11 kV overhead lines.

Makhetha suffered electrical shock and burns to his arms and hands. The Ekurhuleni Metropolitan Municipality Emergency Services was called, and after providing emergency treatment to Makhetha, in order to stabilize his condition, he was admitted to the Intensive Care Unit of the Linmed Hospital, Rynfield, Benoni, for further treatment and observation.

Swanepoel, after submitting the necessary documentation at the Linmed Hospital, proceeded to the site where the accident occurred in order to establish the cause of the accident and to restore the power. Swanepoel also notified Chris Day, engineer (opera-tions and Maintenance), of the incident.



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Post-incident action

Swanepoel discovered that, after close inspection of the overhead line circuit that the yellow or centre phase "cut-out" fuse link at pole no. BB19/B69/1 was bridged out on the line side of the fuse link. The opening of the "cut-out" fuse link, therefore, had no affect on the action taken to isolate the 11 kV power line. Swanepoel, with the assistance of the standby electrician responsible for the town area, B Tabu, isolated the power line at the next point of isolation (viz. "Triswitch" pole no. BB19/B60 in Combrink Road) and successfully completed the necessary repair work at pole no. BB19/B69/4. The power was restored at approximately 18h00.

On Monday 14 June 2004, the area manager, B. Lamprecht and senior officials Day, Barnard and Swanepoel conducted a site inspection. Specific attention was given to the arrangement of the "cut-out" fuse link at pole no. BB19/B69/1 and it was concluded that two possibilities existed, namely that during the upgrading and strengthening of the rural network during the 2000/2001 capex budget, the "cut-out" fuse link could have been wired incorrectly or, since the said upgrade, the fuse link could have been bridged out as a "temporary repair" in order to restore power as soon as possible and was never normalised. At pole no. BB19/B69/6, which forms part of the same circuit, a Delta/Star 11000/400 V pole mounted transformer, is installed supplying the 400 V overhead network in North Road, Putfontein. Since the yellow phase remained energized via the bridged out fuse link at pole no. BB19/B69/1, a back feed was created through the transformer primary winding, resulting in both the red and blue phases at pole no. BB19/B69/4 being live.

Makhetha will be consulted, once his health condition permits such action.

In terms of departmental instructions and operating procedures, and procedures permitted and put forward during in-house training sessions, it is alleged that Motau did not comply with the said standing instructions and procedures, which could be considered an act of gross negligence on his behalf. The necessary disciplinary action will be instituted against Motau.

Steps taken to prevent the recurrence of future accidents

The Acting Operations Officer, J. Bronkhorst, Benoni CCC, was verbally instructed on 16 June 2004, to immediately conduct a survey by means of using a line diagram to physically inspect all similar "cut-out" fuse links as well as any other overhead line isolator equipment installed in the Benoni CCC's medium voltage rural networks, to ascertain the condition and status of such equipment and to report without any delay any irregularities found to the engineer (operations and maintenance) Chris Day, in order to take corrective measures.

Bronkhorst, was to take the necessary corrective measures to have the subject fuse link at pole no. BB19/B69/1 correctly installed on 20 June 2004. On the said date it was established beyond any doubt that the fuse link was bridged out as "a temporary repair" by a staff member unknown at this stage, in order to restore power as soon as possible to the subject area, and the same was never normalised.

A written instruction is to be re-issued to all competent operating staff confirming the previous resolution taken by the Mayoral Committee on 19 February 2004, where it was resolved that as far as practically possible, both sides of any high/medium voltage switchgear, transformers, isolators or equipment, be switched off, tested as "dead" and be earthed on both sides (where applicable) from where it can be made "live" before work is allowed to be carried out.

The investigation team supported the following recommendations of the Benoni CCC, area manager, electricity division:

- "That after isolation of any high/medium voltage overhead line network or circuit, the testing of such a line network or circuit to demonstrate that it is electrically dead, shall be conducted from ground level, making use of a high voltage proximity tester attached to an extendable operating link stick. This instruction will merely reiterate the standard procedure in place, which was the only acceptable procedure permitted and put forward during in-house training sessions.
- That the use of a mobile elevating platform is not permitted until "working earths" have been applied on both sides of the workplace. The application of earths shall be by means of an extendable operating link stick, from ground level.
- That no staff will be permitted, for whatever reason, to bypass any "cut-out" fuse link or isolation apparatus installed on medium voltage overhead line networks, unless specific approval was obtained from a senior staff member."

In addition to the steps already recommended, the investigation team felt that the following new procedures should also be recommended for approval:

If an employee has a reasonable belief that the work to be undertaken is likely to be endanger himself or any other person(s) due to substandard acts or conditions, inadequate precautions or lack of protective equipement or clothing, he/she has the right to refuse to work.

The sole purpose of this is to support and protect the rights of all personnel in the electricity division. Such a procedure is deemed necessary as electricians/artisans unfortunately, from time-to-time, seem to take so called "short-cuts". Due to previous experience or incorrect work methods used over years, they do not always regard it necessary to follow the recommended safe operational procedures.

The requirement to test to confirm whether any circuit is live (meaning switched-on) or dead (meaning switched-off) before being earthed cannot be over emphasized.

The investigation team is of the opinion that with some basic knowledge and training, all personnel assisting electricians/artisans can be made aware of the dangers involved in electricity and can be made aware of the essential steps required to perform work safely on electrical equipment, switchgear, transformers, wires and cables.

These essential steps are as follows:

- A visible circuit element must be switch-off and earthed
- A visible test must be done to demonstrate that a circuit is live (meaning switched-on) or dead (meaning switched-off)
- A visible earth is to be installed to protect the circuit from being electrically charged.

Wherever practicaly possible and only after the above-mentioned procedures have been followed and proven to all involved, e.g. after the application of suitable visible earth(s) to the circuit by the competent person(s), should it be expected that other personnel start work on applicable equipment, switchgear, transformers, wires and/or cables.

Conclusion

The investigating team acknowledges that an abnormal situation existed on the overhead line circuit in that the yellow or centre phase "cut-out" fuse link at pole no. BB19/B69/1 was bridged out on the line (live) side of the fuse link. The opening of the "cut-out" fuse link, therefore, had no affect on the action taken to isolate the 11 kV power line.

If this extremely dangerous and abnormal situation of "bridge out" did not occur prior to the incident, the opening of the fuse links by the electrician, Motau, would have probably isolated the line sufficiently to prevent injury to personnel.

At the investigation, the electrician, Motau, mentioned that he was going to perform a test to determine the status of the line whilst approaching the line with the hydraulic elevated platform.

The investigation team found it unacceptable that he had brought the elevated platform within touchable reach from the injured person and himself before any testing had been performed. It is alleged that Motau did not comply with standing instructions and procedures, which could be considered an act of gross negligence. The necessary disciplinary action will be instituted against Motau.

Should the responsible electrician have followed the prescribed procedure to test the line, with the testing equipment that he apparently had available, the incident could have been prevented.

The down-stream transformer delta winding configuration aggravated the live condition of the line in causing all three phases to become alive by means of back feeding through the windings and with reference to ground (earth).

For the sole purpose of preventing incidents of this nature, it is recommended that the area manager or his delegated persons in the electricity division at Benoni CCC, prepare an informative presentation on the incident practical and factual aspects and share it with all CCC's electricity division operational staff. The sharing of such information may be vital in preventing injury of employees in future.

It is also recommended that the three regional directors of electricity keep a record of attendance to ensure that all relevant personnel under their control attend such a presentation.

Lastly, it should be mentioned that the Electrical Machinery Regulations of the OHS Act state that for work on disconnected electrical machinery (regulation 3):

"Without derogating from any specific duty imposed on employers or users of machinery by the Act, the employer or user shall, whenever work is to be carried out on any electrical machinery, which has been disconnected from all sources of electrical energy, but which is liable to acquire an electrical charge, as far as practicable, cause precautions to be taken by earthing or other means to discharge the electrical energy to earth from such electrical machinery or any adjacent electrical machinery if there is danger there from before it is handled and to prevent any electrical machinery from being charged or made live while persons are working thereon".

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Khai-Ma Municipality	Petrus Bottman	P O Box 108, Pofadder, 8890	(054) 933-0066	(054) 933-0252
King Sabata Dalindyebo LC	Engineer The Electrical	P O Box 57, Umtata, 5100	(047) 501-4304	(047) 531-2704
Klerksdorp LC	Wynand Viljoen	Priv Bag X99, Klerksdorp, 2570	(018) 462-9851	(018) 464-1221
Knysna Municipality	Len Richardson	P O Box 21 , Knysna, 6570	(044) 384-0422	(044) 384-1816
Kouga LC	Desmond Walter Pennels	P O Box 137, St Francis Bay, 6312	(042) 294-0309	(042) 294-1080
Kouga LC	AH du Plessis	P O Box 21, Jeffreysbay, 6330	(042) 293-1111	(042) 293-4488
Kungwini LC	DJ Botha	Posbus 40, Bronkhorstspruit, 1020	(013) 932-0061	(013) 935-1311
Kwadukuza Municipality	LF Klopper	P O Box 72, Stanger, 4450	(032) 437-5018	(032) 551-5500
Kwadukuza Municipality	L Klopper	P O Box 72 , Stanger, 4450	(032) 437-5018	(032) 551-5500
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Lekwa LC	Dawie Lottering	P O Box 66, Standerton, 2430	(017) 712-9819	(017) 712-9816
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Lesedi LC	Hennie Coetsee	P O Box 201, Heidelberg, 2400	(016) 341-3111	(016) 341-6458
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Makana LC	Wally Bute	P O Box 176, Grahamstown, 6140	(046) 622-5264	(046) 622-5264
Makhado Municipality	Kobus Botha	P O Box 96, Makhado, Limpopo, 0920	(015) 519-3227	(015) 519-3132
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Mantsopa LC	HD Potgieter	P O Box64, Ladybrand, 9745	(051) 924-0654	(051) 924-5144
Masilonya LC	FC Meyer	P O Box 26, Winburg, 9420	(051) 881-0003	(051) 881-0003
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Moqhaka LC	Hannes Brews	P O Box 302, Kroonstad, 9500	(056) 216-9283	(056) 216-9284
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Mthonjaneni LC	Peter Hamalainen	P O Box 11, Melmoth, 3835	(035) 450-2082	(035) 450-3224
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Musina Local Municipality	Jackie du Toit	Private Bag X611, Messina, 0900	(015) 534-0211	(015) 534-2513
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Phokwane Municipality	MJM Blaauw	Private Bag X3, Hartswater, 8570	(053) 474-9752	(053) 474-1768
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