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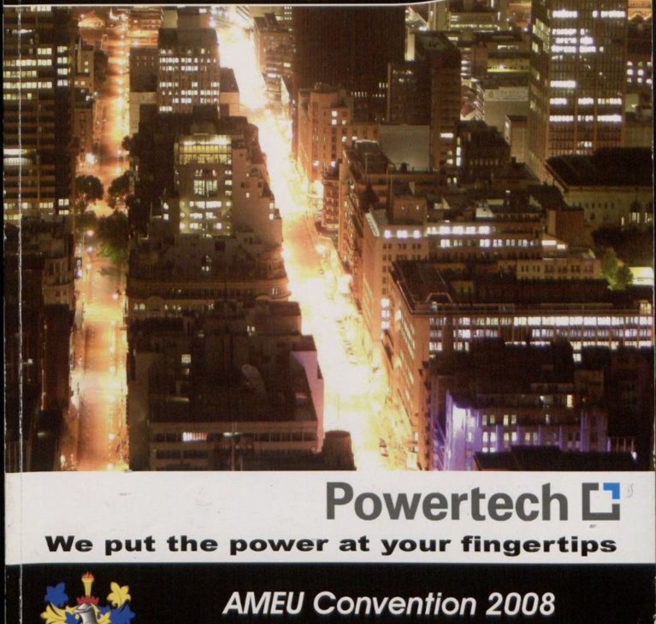

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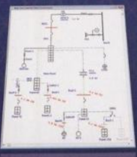

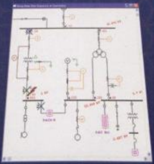

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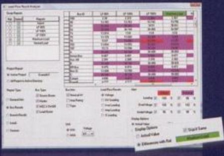

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Powertech: the power of continuous innovation

Innovation: something that has served to define Powertech from the outset. Founded thirty years ago, the Group has become one of South Africa's leading suppliers of electrical and electronic equipment and services, specialising in the manufacture and delivery of world-class electric and electronic business solutions. Norbert Claussen, CEO: Powertech, maintains that Powertech's success is a direct result of incorporating consistent and continuous innovation in all aspects of both the brand and operations.

Information from Powertech

The humble beginnings of what is today a powerful subsidiary of the Johannesburg Securities Exchange-listed Allied Electronics Corporation Limited (Altron), belie Powertech's founders' sustained focus on core markets and growth areas. Founded in 1978, the group has grown from strength to strength, creating a formidable global footprint thanks to its strong business ethics, black economic empowerment (BEE), and continued development of an unrestricted technological and knowledge base.

"Our company's strength is a direct result of our exceptional brands," says Claussen. "Those that comprise our five divisions are not only trusted by industry and within the marketplace but, more importantly, have become well known and respected household brands."

Household brands they certainly are. Lift up the bonnet of your car and you'll no doubt discover a Powertech battery – whether it be Willard or Sabat. The same applies when it comes to the light fittings and sockets in your home in the form of Crabtree accessories. And this is just the beginning of Powertech's formidable brand list. The Group's five divisions – Powertech Cables, Powertech Transformers, Powertech Batteries, Powertech Industrial and Powertech System Integrators – comprise between them some 19 well-established companies. Each of these has enabled Powertech to lead the sectors in which it operates: power utilities, large power users, transport, telecommunications, building and construction.

"Creating what essentially has become a 'one stop shop' for all matters electrical, means that we can essentially 'partner' with our customers no matter what their diverse electrical needs are," says Claussen. "We have the resources and expertise required to meet both the generic and specific demands of our customers. Because we effectively partner with our key clients, we also use them and their unique business challenges as opportunities to innovate and find solutions, often drawing on resources within the group."

Looking at electricity and power from a global perspective means that Powertech has also gone on to establish an international as opposed to local presence – something Claussen believes has been fundamental in driving the business to the forefront of its game. "Being active on a global scale is imperative in this industry. We have worked hard to ensure that Powertech has a significant presence everywhere from the UK to Asia, Nigeria, Tanzania, Kenya, Namibia and Mozambique. By additionally owning companies overseas, such as Alcobre Condutores in Portugal and Cables de Comunicaciones in Spain, we have enabled the group to leverage operational efficiencies, whilst keeping our finger squarely on the pulse of international markets, cross-pollinating skills and innovative new products."

"Exceeding clients' expectations is only possible if you have the right team of people on board," adds Claussen. "To enable innovation, you have to empower your team with the resources, training and support they need to find opportunity in challenges, and work consistently to overcome these. We are committed to investing in our team, ensuring that the Powertech brands trusted by parents today are trusted by their children tomorrow."

While 30 successful years on one could be led to believe that Powertech has reached the pinnacle of its game, Claussen maintains that the next three decades look to require even more innovation and progressive solutions from the Group. "With power demand and supply challenges emerging both locally and around the globe, our role as power specialists and facilitators has become more critical than ever. As such, we're committed to consistently seeking out viable, sustainable, innovative solutions to challenges that weren't anticipated 30 years ago. Ours therefore remains a definite space to watch."







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Welcome by Outgoing AMEU President

Sandile Maphumulo, Outgoing AMEU president

I have great pleasure in welcoming you all to the 61st AMEU Convention being held in the beautiful City of East London, home to the Buffalo City Municipality and our new AMEU President, Sy Gourrah.

The current events within the Electricity Supply Industry (ESI) that have kept us busy through my term of Presidency of this prestigious Association, have set the scene for our Convention theme: "Energy Crisis and the Role of the AMEU", and I trust that we have put together a programme for you that is both interesting and useful. Certainly, for me, my term of office has been challenging and rewarding. Through it all, I have been strengthened in my efforts, as I witnessed the response of many in the municipal environment, going an extra mile to ensure that our customers suffered as little inconvenience as possible and to accept and meet the many challenges facing us.

The AMEU has a proud history of service to our communities, both within our municipalities and in the greater electricity distribution environment. It is of great pleasure to me to see that the organisation is being recognised as a significant player in the industry that can add great value to discussions and processes essential to the service we provide and the events taking place. We will now be entering another historic chapter of this history as I hand over the reigns to the first woman President of the AMEU. I would like to take this opportunity of wishing Sy a successful Convention and a wonderful term of office. She will have the support of every one of us.

The preparation for a Convention of this nature is a large task that is only possible with the hard work and cooperation of a lot of people. I would like to take the opportunity of expressing our gratitude and appreciation to all who have made it possible, especially our Affiliates and sponsors, officials from Buffalo City Municipality and the team from the AMEU Secretariat.

May you all enjoy this Convention and return to your homes safely and with a refreshed spirit to enjoy all of the gifts of life.

Sandile Maphumulo

Outgoing AMEU President

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Inaugural speech by Incoming AMEU President

Sy Gourrah, Incoming AMEU President

- The Honourable Minister of Minerals and Energy, Ms. B Sonjica
- The Executive Mayor of Buffalo City, Honourable Cllr. Zintle Peter
- Mayors from other municipalities
- Mayoral committee
- Councillors
- The Acting Municipal Manager of Buffalo City,
- Directors
- Past President of the AMEU, Mr. Sandile Maphumlo from eThekwini
- President Elect of the AMEU, Mr. Michael Rhode from Stellenbosch
- The CEO of EDI Holdings, Ms. Phindile Nzimande
- Eskom MD, Erica Johnson
- Lesley Ferrando from NERSA
- SALGA
- Members of the municipalities
- Stakeholders in the industry and affiliates
- AMEU EXCO
- AMEU members
- Officials from various national, provincial and regional spheres of government and agencies,
- Members of the media
- Distinguished guests
- International guests
- Ladies and gentlemen
- All protocol duly observed...

It is indeed an honor, privilege and blessing to be inaugurated the president of this prestigious association, the Association of Municipal Electricity Undertakings, Southern Africa, (AMEU) with a 93 year old history.

The Association has grown in strength and partnered with important stakeholders of the industry which is evident with our registration and is playing a strategic role in changes within the industry.

Ladies and gentlemen, this conference themed, *"The Role of the AMEU in the energy crisis"* takes place when the value of partnerships amongst the stakeholders is of utmost and crucial importance for the sustainability and transformation of the industry especially in light of the current energy and skills shortage.

I would like to welcome you to this conference and invite you to partner with the AMEU's bank of expertise, engineers and manufacturers. I hope this conference will prove to be informative, interactive and a platform to exchange ideas.

A special thanks to the speakers, stakeholders and delegates for accepting our invitation and for attending. Thanks to the EXCO of the AMEU, the secretariat and BCM council for the constant support and guidance.

I would like to take this opportunity to thank God, my church and family who have stood by me, especially my parents for making sacrifices so I could be here today, my sisters for their continuous support, my husband and kids – for understanding and managing most of the time without me, my colleagues and friends for being here and especially in pulling this convention together.

Of course we have also provided some fun which commenced yesterday with the sports events, the affiliates evening and today we will be entertaining the spouses, the civic reception is tonight and the gala evening tomorrow.

Once again a warm welcome to Buffalo City and I hope you have a memorable stay and an excellent conference.

I would like to end off with a small quote:

"Only one man in a thousand is a leader of men – the other 999 follow women". (Groucho Marx)

I thank you.

Sy Gourrah, Incoming AMEU President

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Report of the General Secretary to the 61st AMEU convention for the period 2007–2008

by Jean Venter, AMEU General Secretary

The Association, now in its 93rd year of existence, continues to play a strategic role in the electricity distribution industry, representing the interests of municipal electricity distribution undertakings.

The organisation benefits from a well rounded communication process involving regular committee meeting clusters, solid representation on a large number of external committees, regular feedback to branch committees and members. Conventional printed media in the form of annual proceedings as well as three AMEU News editions per year completes the process. The annual convention, and regular branch meetings in all six branches ensures that engineers and councillors around the country can network with each other and share information and experiences in the industry. AMEU Communications are further enhanced and facilitated by Past President, Peter Fowles, who is now serving the AMEU on a full time basis.

During 2008, the Executive Council reconsidered its previous recommendation for a one year term of office for the AMEU Presidents and amended the term to two years. No constitutional changes were required to effect the change. To resynchronise the terms of office of the President with that of the Executive Council, the term of the current Council was extended to three years.

We are also pleased to announce that the Bushveld Sub Branch has been upgraded to the status of a full branch of the AMEU with representation on the Executive Council.

Membership numbers remained mostly static during this period. On the ground, attendance at branch meetings are at a respectable level but some growth in the Highveld branch remains desirable.

Council members again invested exceptional amounts of time and effort in the activities of your Association. The diligence displayed and the family time sacrificed is to the credit of both the municipal electricity distribution and the electrical engineering professions.

The energy crisis remains at the top of the agenda and the AMEU has participated over a broad front in forums and workgroups dealing with the general shortage of generation capacity in South Africa. The need for energy consumption saving, environmentally acceptable practices, and planning for the 2010 World Cup, all consumed time and resources of the organisation.

Financially, the association remains sustainable, providing in my view, good value for money to its members.

Energy security in a resource constrained world

While demand for energy is growing with the economic development of industrialising nations, the availability of resources to sustain this development is limited. The global market for fossil fuels has been impacted by this interaction between supply and demand with consequences for South Africa.

by E Johnson, K Bowen and S Prins, Eskom

Currently the ability to ensure a secure electricity supply has been impacted by high domestic electricity demand growth which coincides with substantial growth in demand for energy (and electricity) in the rest of the world, resulting in higher fuel costs as well as dramatically increased cost of construction and capital equipment. Eskom also has to compete for limited production capacity for key equipment, further constraining time lines and costs of new build. This paper discusses some of the issues regarding the global developments around energy, and then focuses on how these global trends are impacting on security of supply in electricity in South Africa. Of particular importance is the distinction between the adequacy of long term capacity to meet growing demand and the short term reliability of supply.

Resource Constraints

Supply limits

The bulk of energy sources internationally are strictly finite in that there is no feasible capability to replenish depleted resources. Even if additional resources were to be discovered and exploited (for coal, oil and natural gas for example) this does not alter the long term supply concern: that the total stock of the resource (including untapped resources) is falling as it is consumed.

This non-renewable aspect suggests that there will be some point where the resource will be exhausted globally, analogous to the steady and imminent depletion of the North Sea gas fields or the near exhaustion of British coal. However until recently the potential exhaustion of the resource stock had seemed remote, but with increasing demand being placed on these resources the possibility is that the exhaustion point may be approaching faster than expected.

South Africa has coal resources that will last for at least the next hundred years at current consumption. However as local consumption and exports grow the point of exhaustion will get closer. Even before that point it is likely that the costs of extraction will increase as cheaper resources are depleted.

Demand issues

A significant portion of the concerns for energy security is the growing demand for energy globally. This growing demand increases the competition for existing resources with resulting increase in prices in a market environment.

The industrialised world uses the majority of the available global energy. The United States uses about 21,8% of the world's energy resources, while having a share of about 4,6% of the global population. China consumes roughly 14,5% of the total energy produced globally (2005 figures). However growth in demand from industrialised nations is tapering off, to be overtaken by industrialising countries.

The increased demand for energy stems from the dramatic increases in wealth in certain developing countries. This is particularly evident in India and China which have large populations, thus compounding the rise in energy demand. As the human population develops, and countries become more affluent, a relationship between energy consumption per capita and GDP per capita can be expected, since higher incomes mean more appliances and cars, larger houses and other energy intensive activities. This relationship is not linear and depends on factors including but not limited to the non-commercial use of energy as well as energy intensity and the efficiency with which the energy is produced.

The relationship between economic growth and energy demand varies from region to region, as the different factors influencing economic growth and energy demand (e.g. energy efficiency) come to the fore. However the link between energy demand and economic growth is relatively weak in industrialised nations. The opposite is true for developing nations, where demand growth tracks economic expansion closely (Doman, 2004).

Energy intensity (the ratio of energy demand to GDP) is dependent on a country's stage of development. Developed countries which experience significant de-industrialisation (for example, the United Kingdom and USA) generally move toward less energy intensive sectors (financial services, information technology, etc.), while developing nations initially intensify their energy use (with the development of mining and energy-intensive industry such as mineral beneficiation, etc.) until the economy shifts towards services and other less intensive sectors. Fig. 1 indicates how South Africa's energy intensity (measured

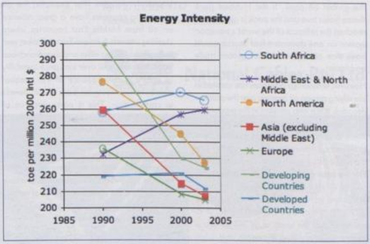

Fig. 1: Changes in energy intensity.

as the tonnes of oil equivalent divided by GDP in 2000 'international' dollars) grew from 1990 to 2000 before dipping by 2004. This latter drop can be explained by the growth in tertiary sectors (such as wholesale and retail trade and financial services) relative to manufacturing and mining (which are more energy intensive).

From an electricity-intensity perspective the relationship between economic growth and electricity consumption has changed over the past decade. Until 1998 the intensity grew along with the energy intensive users adding to demand. Since then economic growth has centred on less electricity intensive sectors of the economy reducing the intensity. Recently the electricity demand has been trending toward a level 2% below economic growth. The expectation is that this trend will continue. As government has stipulated in its ASGISA programme the target economic growth is 6% p.a. for future years. Eskom has adopted a position that 4% p.a. electricity demand growth will be supportive of the ASGISA target.

Energy security

The global energy market is dominated by oil as the primary source of energy for many activities, in particular transport. Thus supply and demand for oil sets the global energy agenda with spin-offs for alternate resources such as coal or gas.

The Hubbert peak theory suggests that at some point production of fossil fuels in a region (or globally) would peak before going into steady decline. The theory has held true in a number of regions, especially US oil production which peaked in 1971 before gradually declining thereafter. Similarly a number of oil producing areas have passed their peak. The question remains whether the global peak has been reached or threatening to occur anytime soon. The price escalation in the past few months owes much to the spectre of reaching or passing the global oil peak. If the Hubbert peak theory holds true and the peak is about to be reached the reliance of the world's transport system on one dominant fuel source would have dire consequences for global trade and travel.

However, technology advances has assisted in identifying proven oil reserves over the past few decades. It has also assisted in the production of oil from previously unreachable locations. These developments have persuaded analysts to be more measured in their views regarding the future of oil reserves. It is now estimated that the peak production level of recoverable oil (i.e. oil that can be recovered at today's prices and technology) should occur around 2020 (Doman, 2004). Thereafter, it is estimated that the levels of oil will go into a decline, with resulting shortages and price increases.

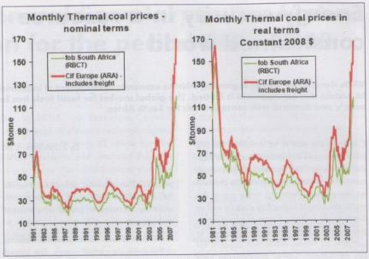

Fig. 2: Thermal coal prices 1981-2008.

A significant dependence on a particular resource increases the fallout from an event or constraint that occurs in that resource, even if the resource is renewable. For example, the prolonged drought in Brazil in the early 2000's which impacted on generation capability from hydro power stations, the main source of electricity generation (83% in 2004), highlighted the vulnerability to a single mode event. Similarly in South Africa the heavy dependence on coal has – at least on the margin – left Eskom exposed to rising international coal prices, as highlighted in Fig. 2.

The distribution of energy resources is not uniform and there is a great reliance on a few regions (even countries) for the supply of essential commodities. Not only is there a market power issue with these countries and their ability to influence pricing of the resource, but all too often these regions are inherently unstable. For example, the oil consuming countries have a great reliance on oil from Middle East countries where clashing interests (between East and West, and between governing elites and disenfranchised poor) regularly spill over into price instability in oil. As a consequence of the unequal distribution of resources there is also benefit to cartelisation. This is particular true of oil where the Organisation of Petroleum Exporting Countries (OPEC) has dominated oil production and pricing since the 1960's. Even though it has had less than 50% of world oil production, most of the excess capacity and reserves fall under OPEC's control. Similarly Russia, being the dominant supplier of natural gas to Europe, has significant pricing power over natural gas in the region.

Liberalising energy markets, especially in the presence of cartels and nationalised energy champions, would provide the correct incentives for investment in extraction and processing capabilities.

A significant concern in the current capacity outlook is that investment in capacity in energy production – be it extraction of oil, natural gas or coal; oil refining or electricity generation – is lagging behind demand growth. In some instances the incentives for additional capacity are distorted (as in Russia and OPEC nations) or instabilities hamper investment.

Investment in coal mining in South Africa has not kept pace with the growing local and international demand for steam coal, due mainly to uncertainties regarding mining rights. This has left a gap in coal supplies to existing and new power stations.

Climate change

The use of energy, its extraction and processing always involve environmental disruption, in the form of geological and ecological disruption, as well as pollution. Other impacts of energy use include noise from transport as well as land-use impacts such as the construction of roads and power lines (Stern, 2004).

Coal is the predominant source for electricity generation in many countries. Its widespread availability makes coal attractive for energy use, despite its higher carbon emission rate, when compared with other resources such as natural gas and nuclear. At current production levels, the known global coal reserves are expected to last another 200 years (Doman, 2004). Coal plays a major role in two of the world's fastest growing economies, namely China and India. Besides being used for electricity generation in China, coal is also an important resource for industrial uses. Linking the reliance of China and other countries on coal and their economic growth projections,

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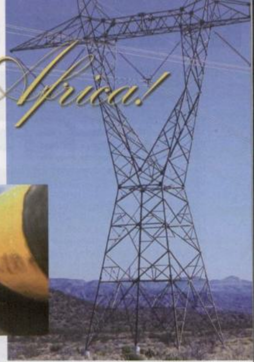

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suggests that coal will be a major source of energy for the foreseeable future.

The Intergovernmental Panel on Climate Change (IPCC) has clearly indicated that it is the burning of fossil fuels that is responsible for increased risk of climate change. Thus the focus for sustainability should be on shifting primary energy sources away from fossil fuels. This will impact on investment decisions regarding new build, toward new technologies that reduce carbon emissions at coal-fired stations (or increase sequestration thereof) and renewable options. In the ISEP-11 plan Eskom has targeted 1620 MW of new renewable capacity (specifically wind and solar options), including the building of a new wind farm of 100 MW by 2010.

Technological change to reduce dependencies and combat climate change

The limitations imposed by existing technology, both in terms of extracting and processing capacity and the usage of energy, will have to be raised. Shifting out the production frontier for energy sources will increase the supply of product to consumers, while dramatic improvements in efficiency can assist in allowing existing volumes to stretch further.

Energy conservation and efficiency

An important mechanism to enhance energy security is to review the way in which energy is utilised. A fair amount of energy is lost to wasteful abuse of the resource. Pricing would take care of a large portion of such wastage by increasing the opportunity cost, but otherwise more stringent energy conservation mechanism are required (through state intervention) to ensure that domestic, commercial and industrial users take precautions against waste, and that producers of machinery and appliances are obliged to improve energy efficiency in the products they sell.

It is also possible that shifting to higher quality energy fuels (with higher calorific values) reduces the total energy required to produce a unit of GDP. It also reduces the environmental impact of the remaining energy use. The use of natural gas instead of coal to generate electrical energy is an example, as natural gas is cleaner burning than coal, and produces less carbon dioxide per unit of energy (Stern, 2004). In areas where the infrastructure is available, natural gas has gained significant market share of the electricity sector. This is particularly relevant in Russia and the EU, where Russia holds 31% of the world's total natural gas reserves, and exports part of this to the rest of Europe (Doman, 2004). The shift in public sentiment and use of natural resources from coal to "cleaner" technologies has allowed countries like Russia to strengthen their international position by using the dependence of other countries on their resource as leverage.

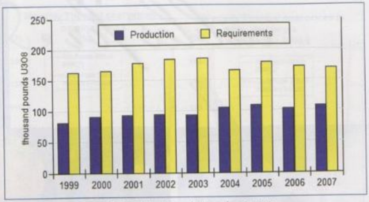

Fig. 3: Global Uranium production and requirements.

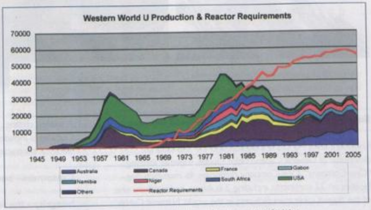

Fig. 4: Long term uranium production and requirements in the West.

Diversification of resources

The Energy White Paper of 1998 highlighted the need to enhance security of supply through diversifying generation fuels. The reliance on coal leaves South Africa vulnerable to shifts in international coal prices (as has been experienced of late) as well as the negative impacts with regard to climate change. Thus the push to diversifying into alternative fuel sources such as nuclear power and renewable resources.

Nuclear power (along with renewable energy sources) has historically found it difficult to compete with fossil fuel in the race to meet growing global energy demand. The cost of nuclear energy relative to coal, especially in a country with cheap coal supplies like South Africa, has reduced the attractiveness of nuclear power. In addition the nuclear industry has encountered political and social opposition following the incidents at Three Mile Island and Chernobyl. Public sentiment against nuclear energy has generally relegated it to the back-burner, and in some countries (for example Sweden and Germany) there has been an active policy of phasing out existing nuclear power stations. However with the growing focus on climate change and the potential for emission caps or taxes on coal usage, there is renewed interest in nuclear as an alternative for base-load electricity.

The concern for nuclear power is the supply of uranium. From 1985 the production of uranium has been significantly lower than the requirements (as shown in Fig. 3), mainly due to the release of supply from existing military stockpiles (in the West and in the East), which at 97% U-235 can be diluted to provide substantial amounts of reactor fuel (at only 4% U-235). This under-investment in uranium production could be problematic in the future should the stockpiles become depleted. Fig. 4 shows how until 1985 uranium production far exceeded the reactor demand, the bulk of that production going into the military stockpiles.

It is interesting to note that since 1999 South Africa's production of uranium has almost halved (from 2,5 million pounds of U_3O_8 in 1999 to 1,4 million pounds in 2007). From a security of supply point of view self-sufficiency in uranium production may be prudent if planning for a large-scale nuclear programme.

Natural gas remains an alternative to coal in some regions where natural gas is abundant. However Europe is finding that with the imminent winding down of the North Sea gas fields it will become even more reliant on Russia as the dominant supplier. Liquid natural gas can act as a break on pricing of piped natural gas, but is a weak substitute due to the costs related to the liquefaction and re-gasification processes. However the growth in LNG trade in the past decade suggests that LNG could substitute for other more expensive peaking alternatives and – in the presence of carbon taxes – may be a viable alternative for mid-term plant.

Renewable resources

Renewable sources of energy hold a number of advantages over traditional (fossil fuel) resources (Goldemberg, 2004). These include the enhancement of diversity in energy supply markets, the securing of long-term sustainable energy supplies, the reduction of atmospheric emissions, the creation of new employment opportunities in especially rural communities and the enhancement of security of supply.

Many countries would like to expand their use of renewable energy resources. Some industrialised nations view the use of renewable energy resources (wind, biomass, etc) as an attractive alternative to coal or nuclear for the purpose of expanding their electricity supply capacity. The lack of negative environmental impact, together with the reduction in carbon emissions counts in its favour. Western European countries, such as Germany, Spain and Denmark, have instituted incentive schemes to help grow the use of renewable energy sources, such as wind, solar and hydroelectric power sources (Doman, 2004).

The use of renewable resources, such as wind, does have its drawbacks. Visual pollution caused by wind farms, together with noise pollution from the turbine blades, can limit the choice of sites. In the power system operations area, the use of wind as an electrical energy resource poses challenges to the utility in terms of optimal location, scheduling of generation dispatch as well as impact on system stability. The above negative impacts are felt to a larger or lesser degree, depending on the contribution of the wind generation to the overall generation capacity.

Hydroelectricity is the biggest and most widely used form of renewable energy in the world. In many developing countries, hydroelectricity is heavily relied upon to provide the required electricity supply. For instance, Brazil, Peru and Chile rely on hydroelectricity to meet up to 80% of their electricity needs (Doman, 2004).

The drawbacks associated with hydroelectricity revolve around the social impact of the construction of the required dams to help drive the generators. Large-scale displacement of parts of the population has been met with resentment in the affected areas, including on China's Three Gorges Dam project, as well as Malaysia's Bakun Dam project. Hydroelectric plants also pose environmental hazards to the surrounding wildlife, including animals and plants due to the disruption of the existing ecosystems. Governments persist with the construction of large scale hydroelectric projects, due to the environmental benefits associated with it, and in an effort to meet the ever increasing demand for electrical energy.

Changing culture

A component of the efficiency argument lies not in the technology employed in the usage of electricity but in the manner in which consumers interact with energy. All too often energy is wasted, not because the technology is inefficient, but consumers are not sufficiently aware of the impacts of behaviour that lead to waste. This is particularly true in a society that has enjoyed cheap energy. Households need to be educated to conserve energy, along with commercial and industrial consumers. Small changes in household behaviour may have a compound effect on the demand for energy, and involve little additional outlay to achieve these benefits.

South Africans have learnt over years to conserve water due to the number of droughts that have highlighted the scarcity of water.

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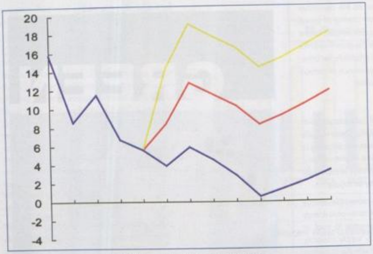

Fig. 5: Net capacity reserve margin 2003-15.

However this same learning has not fed directly through to energy conservation. Perhaps after the events of our "summer of discontent" South African consumers have a different relationship with electricity and only time will tell how this manifests in terms of efficiency, but anecdotal evidence seems to suggest that there remain significant opportunities for further savings at little cost.

Security of supply in electricity

Long term

Reliability of electricity

Over the long term the growing expected demand must be met with significant investment in plant. Over the last decade the reserve margin (reflecting the capacity adequacy of the current system) has deteriorated as supply has not kept pace with demand growth. The immediate concern is on a large scale capacity programme to catch up with demand and overtake it in order to restore the appropriate buffer over demand. Fig. 5 indicates the extent to which the reserve margin has reduced in the recent past as well as projections for the coming ten years under different scenarios. The blue line indicates the projection without any reduction in demand, the red with a 5% reduction and yellow a 10% reduction.

The current Eskom plans (based on ISEP-11) propose the construction of over 50 GW of new capacity between now and 2026. Of this it is expected that up to 20 GW will be nuclear capacity, although there is a limit to the amount of new nuclear capacity that can be added in the timescale. This means that at least 30 GW will have to come from other sources. While some of this may come from renewable energy and natural gas, the bulk is likely to remain coal-based.

The implementation of ISEP-11 involves a ten-year plan including the construction of:

- coal-fired stations at Medupi (4332 MW), Kusile (4332 MW) and a third station (yet to be approved) of similar size required by 2014;
- pumped storage facilities at Ingula (1332 MW) and Lima (1480 MW);
- additional capacity being added to existing open cycle gas turbine stations at Ankerlig (additional 735 MW) and Gourikwa (additional 294 MW).
- A wind farm of 100 MW, commissioning in 2010.

In addition government is planning an IPP open cycle gas turbine of 1000 MW.

If the expected growth (based on the 4% p.a. position) materialises the above plan is required. However there is some uncertainty regarding the impact of the measures adopted to cope with the short term capacity shortfalls in the next few years. If there is a long term impact the growth may not materialise as expected. In addition there is uncertainty regarding policy initiatives around climate change (amongst others) – these would impact on the relative costs of capacity options and therefore the optimal plan. Given these uncertainties, including risks regarding funding of the plans, robust planning is more relevant than ever.

Pricing

The generation expansion programme will require significant capital injection which needs to be covered by revenues in order to sustain the business and provide for a secure and reliable energy supply. Even if all of the capital requirement associate with the build programme could be funded by debt, the increased borrowing costs would have to be funded by increases in prices, especially as the current pricing regime reflects low historic asset values.

In 2008/09 Eskom was permitted a 27,5% increase by NERSA. Similar increases will be required over the next three years (at least) to support the expansion programme. This will lead to at least a doubling of electricity prices.

Energy efficiency

Partly due to the low historic costs of electricity there seems to be a great deal of waste in electricity usage. It is conceivable that with significant price increases over the next few years consumers will be prompted to conserve energy, but there will also need to be a focus from the utility and government to ensure that consumers see the benefits to conservation. This is one of the least cost mechanisms to ensure security of supply and, in the face of climate change, provides for opportunities for each citizen to contribute to saving our environment.

There should be an intensive focus on energy efficiency immediately because it is a powerful options for dealing with the short term capacity issues. However energy efficiency provides significant long term benefits in delaying new capacity as well as reducing the cost of production of existing plant. The benefits for climate change are also clear.

Short term security of supply

The earliest of the major base-load capacity investments will take another five years before they come online. Until then the reserve margin will continue to erode, placing the system in jeopardy from periodic events that could lead to significant disruptions. Thus the focus in the short term falls on demand side initiatives. Given the 4% p.a. growth assumptions the shortfall in capacity is in the region of 3000 MW for the next five years. The following programmes have been proposed to close this gap.

The Power Conservation Programme (PCP) has been developed to manage the shortfall in capacity by constraining demand within the bounds of a secure margin of operation. There are two key arms to this programme, namely:

- Growth Management, which will limit new projects coming on line (at least for demand in excess of 20 MVA) until such time that the system can accommodate the additional demand (either through new capacity or reduced demand elsewhere); and
- The Energy Conservation Scheme (ECS) which mandates that consumers take responsibility for providing energy savings that will allow a return to safe operation. While price increases may assist in incentivising savings, the system will require that mandatory reductions take place in order to allow for Eskom to revitalise its generation capacity through an appropriate maintenance regime (which has suffered in recent years from the reducing reserve margin) and restoring coal supplies to safe levels. The current requirement for the ECS is a 10% reduction in consumption from the 2007/08 baseline determination. The actual demand for the 2008/09 year is currently trending below the expected demand by 4 to 5%, of which some of this

is electricity savings, some weather impacts. It is clear, however, that the 10% is not being achieved through voluntary action.

On the supply side there is an active set of programmes to encourage private participation through independent power production inclusive of co-generation from industry. The three main programmes are:

- The Pilot National Co-generation Programme (PNCP) which provides for co-generation facilities in particular, where Eskom will be the buyer of energy;
- The Medium Term Power Purchase Programme (MTPPP), which allows for independent power production – from whatever fuel source – that meets the price parameters released by Eskom, qualifying for medium term contracts;
- The Multi-site baseload independent power producer programme in which IPPs can tender to sell power to Eskom over a longer period.

It is as yet unclear how much capacity will be achieved through these initiatives, but we know that in the short term there is only a limited impact from the programmes. Thus the PCP is required to ensure that the capacity gap is closed in the short term.

The urgency of the shortfall in the short term is exacerbated by the upcoming sporting events (the Confederation Cup in 2009 and the World Cup in 2010). During these periods the focus on the world will be on South Africa and it is our responsibility to ensure the smooth operation of these events without any interruption. It is thus important that immediate electricity savings are realised in order to allow the necessary maintenance to ensure that the lights keep burning during these events.

Conclusions

It is clear that the issues regarding the supply and demand for electricity do not operate in isolation to other energy sources. The constraints of fuel sources and the increasing demand for energy applies across the board in the energy environment. Thus an Integrated Energy Plan (IEP) has a significant role in bringing these numerous issues together. An IEP can highlight the interaction between competing and complementary fuel markets and attempt to promote efficiency in usage and appropriate investment in capacity to ensure optimal usage of existing resources.

The extent of capacity constraints and demand growth in energy globally was not anticipated by most global players three years ago. This only goes to highlight the uncertainties of planning for a resource constrained operation where constraints appear in delivery, transport, construction amongst others along with shifts in supply and demand. Over and above this the policy environment is as fluid, if not more so, and plans need to be able to adjust, if not anticipate, such changes.

Recent events in electricity and energy in particular highlight the importance of clear and decisive leadership and the importance of promoting efficiency at every level (including the utilisation of technology to support these ends).

The fuels peak may be decades away, but the increasing competition for these resources, as well as the global and local environmental impacts of their exploitation, require that we focus on new technologies and processes to ensure the future security and sustainability of economic development.

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Regulation of the electricity crisis

The National Energy Regulator of South Africa (NERSA) is an economic regulator mandated to regulate the electricity, piped-gas and petroleum pipelines industries. The electricity industry is constantly changing, and has been volatile for some time. The crisis of supply experienced at the beginning of 2008 has led to a number of extraordinary interventions to try to address the issues highlighted by the unavoidable load-shedding.

by Lesley Ferrando, NERSA

NERSA

NERSA is a regulatory authority established as a juristic person in terms of Section 3 of the National Energy Regulator Act, 2004 (Act No. 40 of 2004). NERSA's mandate is obtained from this Act, and the Electricity Regulation Act, 2006 (No 4 of 2006), the Gas Act, 2001 (Act No 46 of 2001) and the Petroleum Pipelines Act, 2003 (Act No 60 of 2003). Further mandate is obtained from published government policies, cabinet decisions, and regulations issued by the Minister of Minerals and Energy. NERSA is expected to pro-actively take the necessary regulatory actions in anticipation of and/or in response to changing circumstances in the energy industry.

The Energy Regulator consists of nine members, five part-time and four full-time, supported by a secretariat under the direction of the CEO. The CEO, Mr. Smunda Mokoena, is one of the full time members, as is Mr. Thembani Bukula, the full-time member in charge of electricity. The Electricity Regulation Division currently consists of the Electricity Pricing and Tariffs Department (PTE); Licensing and Compliance Department (LCE); Regulatory Reform Department (RR); and Electricity Infrastructure Planning Department (EIP).

Some of the regulatory functions of NERSA, as contained in the relevant legislation, which have specific relevance to electricity and the recent load shedding, are:

- Issuing of licences with terms and conditions
- Setting and/or approving tariffs and prices
- Monitoring and enforcing compliance with licence conditions
- planning for the country's future electricity demand/needs (National Integrated Resource Plan)
- promoting alternative electricity generation technologies e.g. Renewable Energy, Cogeneration
- promoting demand side management and energy efficiency initiatives
- Dispute resolution including mediation, arbitration and the handling of complaints
- Setting of rules, guidelines and codes for the regulation of the three industries
- Promoting the improvement of the efficiency of the energy industry
- Consulting with government departments and other bodies with regard to industry development and regarding any matter contemplated in the three industry Acts
- Performing any activity incidental to the execution of its duties (such as Ad-hoc inquiries)

Electricity supply shortage

No-one in South Africa can be unaware of the serious electricity supply constraints experienced in 2007 and particularly during January 2008. This was due to a few adverse factors which came together to create a scenario which resulted in extensive and ongoing power outages and load shedding.

Of course the more localized Cape supply constraints occurred in 2006, providing an early warning of things to come. This started to sensitise the population, but the average South African was for the most part blissfully unaware of anything to do with electricity supply other than having to pay their bills. The load shedding catapulted them into becoming rapidly more informed and energy wise, even if they were not very well-equipped to respond!

Load shedding enquiry

In terms of NERSA's mandate, the Energy Regulator decided that an inquiry be conducted in terms of sections 4(b)(ii) and 4(b)(iv) of the Electricity Regulation Act, 2006 into the national electricity supply shortage and the subsequent load shedding by Eskom for the period 1 November 2007 to 31 January 2008.

An Ad-hoc Subcommittee was established to conduct the enquiry. The following work streams were set up:

- Load shedding
- Primary energy
- Plant Maintenance
- Supply/demand balance
- Legislation and License conditions
- Customer communication and coordination
- Government's National Electricity Emergency Programme
- Financial and Economic implications
- A Communication work stream worked on a communication plan to consider how the findings of the inquiry should be communicated.

While various delays were experienced, the load shedding enquiry report was finalized in May 2008 , and a number of recommendations were made. Some of the key findings as detailed in the press statement of 19 May 2008 were:

- High unplanned maintenance and load losses combined with the usual high planned maintenance of generating units during the period resulted in reduced generating capacity being available from 1 November 2008 to 31 January 2008. Poor coal quality, wet coal and low stockpile levels contributed to the unplanned generation plant outages and load losses in the period
- In previous load forecasts, Eskom had planned for the current growth rate. However, the implementation of measures to provide for the growth has been inadequate and slow. In particular, there have been delays in returning the mothballed generation plant to service and the implementation of energy efficiency and demand management initiatives remain behind targets. Eskom's new build programme is experiencing delays of at least a year
- Inadequate primary energy procurement and power station production planning impacted coal stockpile levels in the period. Coal stockpiles were allowed to decline to unacceptably low levels and there was a reluctance to obtain supplementary coal due to its high cost and impact on Eskom's financial position
- Eskom was correct in declaring a force *majeure* on 24 January 2008. Prior to load shedding, Eskom did use other emergency options such as demand market participation (DMP) and interruptible loads extensively prior to load shedding

The Energy Regulator made the following key policy recommendations:

- The Government's National Electricity Emergency Programme (GNEEP), including the Power Conservation Programme (PCP), should be coordinated and led by a centralized high-level government unit with authority to take action
- The procurement of new private generation capacity, independent power producers (IPP's) and co-generation, should be

managed and coordinated centrally by a professional entity independent from Eskom

- There is a need for a national strategy to be developed by Government for the acquisition and management of coal to ensure security of supply
- National Government should consider formulating a policy that will balance Eskom's commercial decisions and the national security of electricity supply in order to avoid national crises
- The role of Eskom in the Government's National Electricity Emergency Programme (GNEEP) should be clarified considering that Eskom has to focus on returning the system to normality and on its new generation build programme

The Energy Regulator also recommended further investigation in the following areas:

- Primary energy management and in particular coal management in Eskom
- The availability, adequacy and optimum utilization of Eskom's generation plant in emergency and in view of the mid-life of these plants
- National integrated resource planning (NIRP)

There is no doubt that a substantial contributor to the load shedding was the delay in approval to build new generation capacity.

It is the responsibility of National Government to establish an integrated resource plan to give effect to national policy, as defined in the definitions of the Electricity Regulation Act, 2006 (Act no 4 of 2006) ("the Act"). NERSA interacts with the Departments of Minerals and Energy (DME), Public Enterprises (DPE) and Finance (NT) to ensure informed regulatory decisions by the Energy Regulator and better policy decisions by Government.

The National Integrated Resource Plan (NIRP) is an essential regulatory tool which provides key information for the economic regulation process of the Energy Regulator. It is important to have an independent view against which to make regulatory decisions. This plan is the responsibility of NERSA's Electricity Infrastructure Planning Department (EIP).

Maintaining adequate reserve margin is of utmost importance. The previously adequate margins have declined over the past few years due to high demand growth and delays in decisions regarding building new capacity, and this led to the current situation where a reserve margin of <7% is available, against a target of 19% (from the NIRP3).

The NIRP3 is currently being updated by reviewing the underlying assumptions. While there are constantly changes occurring to the factors underlying this planning tool (such as demand growth and progress on the build programme), it gives a fairly clear picture of the generation capacity required in the future. This clearly indicates that despite current initiatives, supply constraints could be experienced until at least 2013 and probably later.

The Energy Regulator approves generation licence applications, and has revised internal processes to ensure that the time required to assess and approve generation licences is minimized.

This year the Energy Regulator has approved the applications for Eskom's Medupi and Bravo Power Stations as well as the return to service of Komati and Grootvlei.

In addition, Eskom has embarked on several programmes to procure the much needed capacity from IPPs. These are the Pilot Cogen National Programme (PNCP), the Medium Term Power Purchase Programme (MTPPP) and the Multi Site Baseload IPP Programme. The PNCP was finalized in September and the Energy Regulator is awaiting a close out report from Eskom.

Power conservation programme (PCP)

The national government response to the load shedding led to the formation of a National Electricity Response Team (NERT), tasked with determining the best way forward in order to determine an immediate and medium term strategy to mitigate the adverse social and economic impact of energy shortages.

Besides addressing issues such as ensuring additional generation capacity, the main thrust or the response has been to facilitate the immediate reduction of energy usage by 10% and encouraging customers to become more energy efficient. This approach, part of a national demand management strategy, has been called the Power Conservation Programme (PCP) and deals with a number of aspects of electricity consumption.

While it was initially hoped that the PCP could be implemented within weeks of the load shedding, consideration of the complexities involved has led to a more measured but better structured approach.

NERSA has been extensively involved in development of the PCP, particularly the legislative/regulatory and governance aspects. Substantial consultations, discussions and workshops have occurred with other participating stakeholders.

The key areas covered by the PCP are:

- Energy Growth Management
- Energy Conservation Scheme
- Pricing

NERSA is bound by its mandate, and has engaged with Eskom, DME and DTI and other stakeholders in finding solutions to some of the

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identified legislative restrictions, to facilitate the regulatory framework required.

Rules governing the different aspects of the PCP have been drafted, and attempts are being made to align all the elements.

It has been necessary to ensure that the rules are not only implemented by Eskom, but can be carried through in the process, through municipalities and resellers, to ensure the correct processes and end-use behaviour of all customers.

A general public debate took place in Johannesburg on Thursday 24 October 2008, which highlighted the real concerns of industry stakeholders regarding the practical implementation and far reaching economic impact of the situation we are in.

A workshop with participating stakeholders will be arranged soon, after which the regulatory process including public consultation will be followed before the Rules are promulgated.

Electricity prices

While electricity prices in South Africa have in the past been some of the lowest in the world, that scenario is rapidly changing.

In December 2007, the Energy Regulator approved a 14.2% increase for Eskom, well above the rate of inflation. This was followed almost immediately by Eskom's revised application for a 60% nominal increase, largely based on additional primary energy costs and accelerated demand side management to ease the shortage of supply. The Energy Regulator's decision on 18 June 2008 to allow a 27.5% increase was taken after careful deliberation, and sought to ensure that all available sources of funding be utilized, including government and international capital, rather than passing the full burden onto electricity tariffs.

A word of caution, however, is that the press statement released at the time states:

"The principle of smoothing prices is supported as part of the Multi Year Price Determination. If the current economic climate continues to prevail and Eskom's capital expenditure programme remains as currently stated, then tariff increases of between 20% – 25% per annum are projected over the next three years."

As we are all aware, there has been a marked deterioration in the economic climate since then, as well as a downgrading of Eskom's credit rating by some agencies and turmoil in the international financial market affecting availability of international capital. This can only have a negative impact on Eskom's ability to acquire much needed funds from the international market and ultimately negatively impact the price of electricity for the next three year period.

Eskom has not yet submitted an application to the Energy Regulator for the 2009/10 financial year and thus the quantum of the increase is yet not known.

Eskom's price has a direct and substantial impact on the costs faced by municipalities, as well as on the tariffs which municipalities in turn charge their own customers.

The Energy Regulator has to balance the need to keep electricity tariffs as low as possible in order to stimulate economic development and provide accessible services to customers, while also ensuring a sustainable electricity industry. This task is becoming even more challenging as the international economy becomes more volatile.

Legislation

The initiatives to address the supply shortage and load shedding highlighted gaps in legislation, affecting the ability of entities to implement some urgently required measures such conservation tariffs.

This led to changes to the Government's DRAFT Electricity Pricing Policy, published in the Government Gazette on 20 June 2008 for comment; the promulgation of draft electricity regulations for comment, which received extensive stakeholder comment and NERSA has worked extensively with DME and the task team to address these comments; and the finalization of the National Energy Bill focused on ensuring "that adequate energy resources are available, in sustainable quantities and at affordable prices, to the South African economy in support of economic growth and poverty alleviation, .."

Regulatory reporting manuals

One of the challenges highlighted in the load shedding inquiry was the difficulty in accessing adequate information essential to making informed decisions. This has long been an area highlighted as requiring substantial improvement, and the Energy Regulator has been working on developing better processes.

The Energy Regulator approved the Regulatory Reporting Manuals (RRMs) for the regulated electricity, piped-gas and petroleum pipeline industries in July 2008.

The gazetted manuals are effective from 1st September 2008 and implementation will start on a staggered basis to accommodate the different levels of readiness of different stakeholders. Volume 1: General Regulatory Reporting Procedures and Administrative Matters and Volume 2: Electricity will be most applicable to the AMEU members. The purpose is "to prescribe and provide guidance to the regulated entities in the Electricity Industry on the format, content, preparation and submission to the Energy Regulator of required information to perform its functions".

The manuals are posted on the NERSA website (www.nersa.org.za) and the implementation plan will be finalized and posted to the website shortly.

Single buyer

Cabinet decided in August 2007 that Eskom should be designated as the single buyer of all independent power producer (IPP) electricity generation in South Africa.

NERSA responsibility, in addition to its standard regulatory functions (such as licensing of power plant) in facilitating this scenario includes:

- Issuing guidelines, rules and procedures for power procurement
- Issuing guidelines and rules for the economic dispatch of IPP plant and Eskom's own generation
- Approval of standard commercial agreements between the single buyer and the IPP including but not limited to power purchase agreements, fuel supply agreement, transmission connection agreement, implementation agreement, transmission use of system agreement and standard tender/bid documents
- Approval of new commercial agreements with IPPs, subject to compliance with procurement guidelines and rules
- Conducting periodic audits of the single buyer procurement processes and Eskom's system operation dispatch function

Conclusion

Many factors have come together over the past 12 months which have substantially changed the industry we operate in. Some facts cannot be avoided, including that:

- South Africa has a serious shortage of electricity supply which will impact the industry for at least the next 10 years. Customers will no longer be able to rely on unlimited capacity
- The price of electricity will rise substantially over the next few years
- The nature of the generation market will change substantially, to include alternate energy sources, co-generation and independent power producers
- Changes in consumption will have to be effected as a matter of urgency
- Regulation of the industry will become even more complex
- The implementation of the PCP will have a substantial effect on all customers

The Energy Regulator is aware of the serious challenges to be faced in the coming years, but is determined to rise to the challenge and ensure that everything possible is done to address these challenges in the very best way possible, to the ultimate benefit of customers, the electricity industry and the economy.

Acknowledgement

Input provided by NERSA staff including Mbulelo Ncetezo, Executive Manager: Electricity Regulation; Simphiwe Makhathini, Head of Department: Regulatory Reform; Nokwazi Makanya, Economic Analyst: Regulatory Reform.

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The A1140 meter is suitable for measuring combinations of active energy, four quadrant reactive energy and kVA. Maximum demand, time of use, load profiling and pulse output functionality is provided as standard.

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A flexible carrier system for communication modules for the A1140 provides the user with a means to select the most cost effective and appropriate communications method for AMI systems. Fitting communication devices neatly under the terminal cover provides a high degree of protection against fraud or tampering. The carrier solution future proofs any A1140 applications as next generation communication solutions can be easily fitted to the meter as they emerge in the future.

Communications are provided via a serial port on the A1140 that can be multi-dropped up to 10 meters from a single communications device or via an optical (IEC 62056-21) port available. The A1140 supports data stream mode, allowing fast reading of meter data and 90 days of load profile data can be downloaded in less than 30 seconds.

The liquid crystal display has large clear 9,8 mm characters that can be viewed from a wide angle. The display sequence is programmable and is supported by two modes of operation, default and utility. Displayed information can use English descriptors or OBIS (Object Identification System) codes.

Programming of the meter can be performed using Elster's flexible well established and easy to use Power Master Unit software that provided a user friendly Windows graphical interface for programming the meter and reading meter data.

The A1140 meter is complimented by a locally designed GSM/GPRS modem that provide a flexible and affordable AMR solution. For security, the modem fits under the sealable terminal cover of the meter. The modem powers directly from the meter's serial port, making installation easy and fast.

The *alpha* A220 and A1140 meters are stock items that are locally available from Elster Kent Metering in Johannesburg. Please contact us for pricing and availability.

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Numbers and needs in local government

The research carried out for the publication 'Numbers and needs, addressing imbalances in the civil engineering profession' highlighted a number of glaring challenges. Of importance was the fact that municipalities were desperately short of civil engineering professionals (engineers, technologists and technicians) whilst students and graduates were battling to find experiential training and employment opportunities.

by Allyson Lawless, SAICE Professional Development and Projects

At the same time many experienced engineers who had been encouraged to take early retirement were available to return to the coal face. A programme was thus initiated in which retired engineers, paired with students and graduates were deployed in municipalities to address service delivery, at the same time as offering training and workplace experience to the young people. The experiences, successes and recommendations of the teams deployed were compiled and published in the book 'Numbers and Needs in Local Government' in November 2007. The overriding conclusion of their experiences and the research carried out both locally and internationally is that the civil engineering capacity in local government is too low to deliver, operate and maintain local government infrastructure in a sustainable manner. The key recommendations are to rebuild structures, rather than embark on further restructuring exercises, and professionalise rather than politicise the appointment of technical staff. Systems, processes and organograms supporting career pathing and professional development should be redeveloped, linked with technical competency profiles to ensure that our national assets are adequately developed, operated and maintained. The findings relating to civil engineering apply equally to electrical engineering.

Background

Recognising the need to address the skills challenge in local government, the project known as ENERGYS (Engineers Now Ensuring Rollout by Growing Young Skills) was rolled out in some 70 municipalities. Teams of retired engineers, paired with students and graduates were deployed in municipalities to address service delivery, at the same time as offering training and workplace experience to the young people.

Naively it had been thought that the deployed teams would contribute significantly to service delivery, and development of the young people. Sadly the teams were hindered in their progress by the many maladies which beset local government. These included reducing technical capacity; little recognition of professional judgement; inexperienced management and lack of decision making; the loss of institutional knowledge, missing data sets and the demise of many systems. Long and complex processes affecting purchases, the award of tenders and the appointment of staff further exacerbate the situation.

The ENERGYS senior deployees were harnessed to research the many bottlenecks and develop policies and recommendations on turnaround strategies to assist their municipalities rebuild capacity, systems and processes. International research was also carried out to understand norms and standards with a view to supporting or enhancing the recommendations being compiled. Emanating from this input 'Numbers and Needs in Local Government' was published in November 2007.

Structure of the report

To develop and motivate the many changes required in the future, technical successes of the past were explored and compared with the present capacity, processes and approaches. The benefits and weaknesses of the various approaches are analysed including the consequences of reduced engineering capacity, expenditure and policies on quality and long term growth. Looking forward, structures, capacity and modifications to policies are proposed to create a more enabling environment for service delivery.

Electrical engineering

Since the processes, challenges and recommendations apply equally to electrical engineering, it was thought that sharing the findings would be of value to the august group that make up the AMEU.

The past

Civil engineering service delivery in local government until the late eighties

In apartheid South Africa, established local government served some 14 million people, at a time when there were well populated structures boasting 2500 to 3000 civil engineering professionals. This translated to some 20 civil engineering professionals per 100 000 people.

Efforts were concentrated largely on town and city dwellers, as well as on the development of infrastructure to support industry, tourism and other land uses that earned income for municipalities through a substantive rate and service base. As a result of the continuous flow of income, funds were generally available for ongoing operations and maintenance (O&M).

There was an adequate number of technical staff to handle the complete civil engineering process, including planning, design, documentation, construction and O&M. In effect, the engineering department was client, service provider, and financier, offering consulting and contracting services for new projects, as well as O&M, while the local authority either provided finance or was able to raise its own funds through commercial loans.

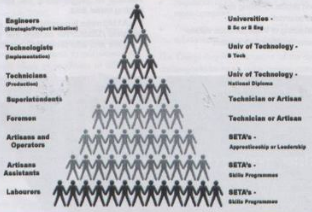


Fig. 1: The technical team and related qualifications.

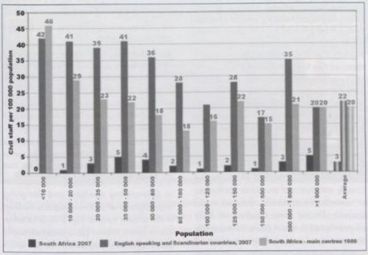


Fig. 2: English-speaking and Scandinavian versus South African municipalities: civil staff per 100 000 population.

A complete hierarchy of technical staff was in place to attend to development and O&M. See Fig. 1. Junior staff would learn much about local government from superintendents and artisans when placed in O&M teams.

The need for staff development was well understood. Young engineers and technicians gained workplace training under the watchful eye of those more experienced. Career pathing was in place and youngsters progressed up the corporate ladder as they became more competent, without the need to move to another municipality.

The City Engineer was the most senior civil engineer and was one of the most powerful people in the municipality. He controlled huge assets and infrastructure budgets, and made both short- and long-term decisions about the development of bulk and end user infrastructure. He was responsible for town planning, building control, architecture, land survey and all civil engineering infrastructure. He was generally an astute, highly qualified registered engineer with years of experience in local government. The City Electrical Engineer was no less qualified or experienced.

Tried and tested processes and systems were in place in terms of short- and long-term planning, budgeting, managing development and building control, handling emergency as well as planned maintenance, and detailed records including drawings, designs and contracts were maintained for reference by all.

The move to outsourcing

Towards the end of the eighties, in line with international trends, design and construction were increasingly outsourced to the private sector i.e. to consulting engineers and contractors. Thus began the slow but sure breakdown of the tight-knit teams that planned, developed, operated and maintained municipal engineering infrastructure. In the move to transfer design and detailed planning to consulting engineers, little thought was given to the need to retain planning capacity to attend to long-term and master planning. By relying more and more on contractors to handle all new projects, the need for teams of artisans and labourers and maintaining fleets of yellow machines and other equipment reduced. This has affected local government's ability to respond to emergencies and effectively handle ongoing maintenance.

The REDs

Electrical engineering faced a further challenge as a result of the announcement of Regional Electricity Distributors (REDs). It was 16 years ago that here in East London, the AMEU conference erupted as the concept was introduced and discussed. The decline in municipal investment, maintenance, staffing and training with respect to electrical services commenced at that stage, as municipalities were loath to invest in assets which would soon not be their responsibility.

The present

Restructuring in the New South Africa

In the new South Africa, restructuring and rationalisation resulted in many technical staff being offered packages at a time when local government was being expanded to serve some 44-million people and service backlogs were enormous. Furthermore, senior technical posts were considered to be management posts and technical staff were replaced by non-technical managers. Support services were moved into central non-technical structures, further reducing the technical direction and input into processes and decisions.

Over the years technical staff losses have continued and today the ratio of civil engineering professionals per 100 000 people has dropped to a paltry two. The drop in the number of electrical engineering professionals has been no less spectacular, further complicated by the fact that few municipalities have any technical staff with Government Certificates of Competance (GCCs). This presents a huge challenge as service delivery can no longer be business as usual, but requires experience and creativity to address massive backlogs and put systems in place to ensure that services are sustained.

Reducing numbers and budgets being focused on the millennium development goals has meant that little attention has been paid to developing infrastructure to attract and support industry, appease increasingly frustrated rate payers or attend to operations and maintenance. The number of technical staff is now just too low to cope with infrastructure challenges.

Whilst it may be expected that the numbers required would be lower than in the eighties, an international scan shows that we were already trailing the English speaking world at the time and nowhere is any developed country near the South African lows which are now in place, as can be seen in Fig. 2. Figures gathered from centres in the neighbouring states indicate that the average number of civil engineering professionals per 100 000 in these countries is just below ten.

The consequences of reduced technical capacity

As a result of the limited technical capacity targets are not being met, infrastructure is failing and sadly backlogs are being developed. The consequences are outlined below.

Planning

As discussed, detailed planning is now handled by the private sector. The need for forward and master planning has not been understood and therefore this planning has fallen by the wayside. Timeous expansion of bulk infrastructure rarely takes place. The Eskom capacity challenges are indicative of this trend.

The lack of planning gave rise to the Integrated Development Plan (IDP) document, which was meant to guide municipalities through the planning process. Unfortunately without technical, transport, economic, town and regional planners developing and maintaining long-term plans, IDPs have generally become "wish lists" made up of many isolated and often non-strategic projects.

Development

With limited technical capacity to adequately specify projects, manage service providers, review designs and monitor contractor progress, funds are being wasted on much abortive work. When investigating projects underway in municipalities to which ENERGYS seniors were deployed they found that only 51% of capital/MIG projects were completed satisfactorily (with the normal niggles). The balance had either failed due to poor design, inadequate contracting, or required major interventions to ensure they were eventually completed.

Operations and maintenance

The challenges in O&M are well known. Water and effluent quality which do not comply with national standards, outbreaks of waterborne diseases, reduced water pressure, limited water supplies, etc have all manifested in recent years. Failing roads have prompted many industries to close off supply lines crippling those from whom they purchased.

Blackouts have become commonplace. Switchgear in many areas is over 50 years old. Funds have not been provided as prescribed by the National Energy Regulator for the renewal and maintenance of equipment. The situation is not only dangerous for operating personnel, but the risk of substation explosions is very real.

Systems and processes

The loss of institutional knowledge, data, and dismantling of systems and procedures exacerbates the already precarious situation. There is limited control over developers from whom considerable sums could be earned by way of bulk contributions; water and electricity losses continue to soar as readings and accounts are not adequately managed; tariffs are not reviewed; and processes to ensure that emergencies are logged and attended to are often non-existent!

In other areas, the development of systems and controls have all but brought service delivery to a standstill. Purchases and appointing service providers has become a nightmare through the complex supply chain process; appointing staff through the HR process has become long winded and rarely yields the correct result as technical applicants are often selected by non-technical staff. Training programmes simply do not get off the ground as a result of the complex skills development process and paperwork which must be filled in! Reporting has also becoming a time-consuming process which robs technical staff of many hours of productive time.

The future

Clearly it is time for action. It will be necessary to rebuild technical capacity and review systems, processes and structures to create a more enabling environment for service delivery.

Rebuilding technical capacity

Rebuilding capacity will require a multifaceted approach including:

- Redesigning organograms to ensure that sufficient and appropriate positions exist to supply and service infrastructure and support ongoing training
- Implementing comprehensive selection and training schemes to develop a new cadre of engineering professionals
- Creating an environment that will entice those with experience back into senior technical positions and ensure that those with experience remain

In determining numbers and designing organograms all technical aspects outlined in the project cycle in Fig. 3 must be taken into account. Master plans based on sound asset registers should inform the IDP which should outline the full spectrum of activities required, including numbers and levels of technical staff.

Overall numbers required

As outlined, the number of civil engineering professionals employed in local government has dropped to a level which can no longer support or sustain service delivery. Studying work breakdown structures and the few municipalities that were coping, when carrying out research for Numbers and Needs, suggests that at least one civil engineering professional is required per 20 000 population i.e. five per 100 000 population.

A more rigorous formula given below has been developed which is linked to households and the service authorities assigned to each municipality.

The household formula

The number of civil professionals required, based on households is designated NH, and is calculated as follows:

$NH = 1 + ROUND\ (N/5\ 000 * \Sigma CEF/9)$

Where,

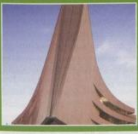
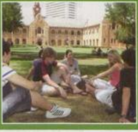
ROUND refers to the rounded value in the brackets. If the decimal value is less than 0,5 the whole number should be adopted. If the decimal value is greater than or equal to 0,5 the next whole number should be adopted

N = number of households, and

$\Sigma CEF = a + b + c + d + e + f + g + h + i$ (the sum of the civil engineering functions performed in a municipality)

Score 1 for each of 'a' to 'i' if the following functions are performed or 0 for each function that is not the responsibility of the municipality

Short Courses and Postgraduate Studies in Energy Efficiency and Demand-side Management

The University of Pretoria has been awarded to host the South African National Hub for the Postgraduate Programme in Energy Efficiency and Demand-side Management (DSM). In response to this, the University of Pretoria has established postgraduate degree programmes specialised in energy efficiency and DSM. Analytic techniques from engineering and optimisation are the main tools in the quantitative study of energy efficiency related topics such as power system scheduling, power system efficiency with alternative energy resources and co-generation, motor and transportation efficiency, fuel efficiency, and energy efficient architecture and housing. The study extends also to DSM schemes, smart load control and computer networks, and efficient lighting. These research topics are clustered among different research groups across faculties within the University of Pretoria: power and energy systems, industrial electronics, electric drive and transportation, control and computer network systems, process integration in chemical engineering, fluid dynamics and heat transfer and architecture and housing, in the Department of Electrical, Electronic and Computer Engineering, Department of Chemical Engineering, Department of Mechanical and Aeronautical Engineering, Department of Civil and Biosystems Engineering and Department of Architecture.

The Hub is also to run the following short courses to develop and enhance knowledge in energy efficiency and DSM in support of accelerated and shared economic growth in South Africa while earning CPD points:

- Industrial Applications of Energy Optimisation (5-6 March 2009, Dr. JF Zhang)
- Power Distribution Engineering (5-6 March 2009, Dr. R Naidoo)
- Energy Efficient Electric Drives (20–24 April 2009, Prof. MN Gitau)
- Energy Efficient and Solid State Lighting (24-25 August 2009, Prof. FW Leuschner)
- Heat Transfer (22-23 September 2009, Prof. J.P. Meyer and Prof. L. Liebenberg)
- Process Integration for Energy Efficiency Improvement (12-13 October 2009, Prof. T Majozi)

The detailed information will be published on both websites of the CE@UP – http://www.ceatup.com and the Hub – http://eehub.up.ac.za.

General enquiries can be made to: Professor X. Xia, Director
National Hub for Postgraduate Programme in Energy Efficiency and DSM
Centre of New Energy Systems - University of Pretoria
E-mail: xxia@up.ac.za - http://eehub.up.ac.za

The administration of the Hub is managed at the Centre of New Energy Systems at the Department of Electrical, Electronic and Computer Engineering.

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a = planning (every municipality should perform a planning function!)
b = road service provision
c = stormwater service provision
d = sanitation service provision
e = solid waste service provision
f = traffic engineering and transport planning
g = water service authority
h = water service provision
i = has a PMU

If a municipality predominantly supplies dry sanitation and limited water-borne sewage networks, set 'd'=1/2.

As an example, a small town with 10 000 households that does not have a PMU and is located in a district that carries the water services authority and provision function would score as follows:

a = 1 – does perform the planning function
b = 1 – is responsible for roads
c = 1 – is responsible for stormwater
d = 0 – is not responsible for sanitation
e = 1 – is responsible for solid waste
f = 1 – is responsible for traffic and transport planning
g = 0 – is not a WSA
h = 0 – is not responsible for water
i = 0 – does not have a PMU

that is, $\Sigma CEF = 5$

$(N/5\,000) * \Sigma CEF/9 = (10\,000/5\,000)*5/9 = 10/9$

This would round to 1, making the total number of civil staff required = 2

that is, $NH = 1 + ROUND(10/9)$

With no water, sanitation or PMU responsibility, the two staff members would be devoted to roads, traffic and solid waste. One would possibly handle the strategic issues and capital projects and the other would manage O&M.

Further adjustment factors have been determined taking into account land use factors other than households such as business, commercial, industrial, mining, education, etc.; the additional burdens due to urbanization; large geographical areas; municipalities made up of many dispersed former towns and villages; rugged terrain and a host of other factors which increase the load on technical staff.

Applying the set of formulae across the board suggests that at least double the number of civil engineering professionals is required in local government in South Africa today i.e. some 2500 to 3000. For more details on the application of the formulae purchase Numbers and Needs in Local Government from SAICE, Tel 011 805-5947.

A similar approach may be adopted to determine the number of electrical engineering professionals required, considering the range of responsibilities including generation, transmission, distribution etc. In moving to the REDs model little will be gained if there is inadequate capacity to plan and manage improved services.

Competencies

The project cycle is shown in Fig. 3. The competencies required to ensure that appropriate solutions are developed and are adequately operated include the ability to liaise and negotiate with the client (in this case the consumer and/or the politician on behalf of the consumer), plan, design, develop contracts, manage construction and manage operations and maintenance. Such skills are required in each engineering discipline in local government i.e. electricity, water, sanitation, roads, transport, amenities, housing and solid waste.

Competency frameworks must be developed to ensure an adequate supply of such skills. Hierarchies of young, mid-career and experienced professionals must work together to address all levels of service delivery. The young to carry out simple tasks from which they will gain sufficient experience to progress to the production phase, the mid-career professionals to take responsibility for day-to-day production, and senior professionals to offer strategic direction, overall management and mentoring of young staff. The skills level of the most senior person per department would be determined in relation to the most complex service offered by that department.

Chief Engineer

In order to re-emphasise that the core business of local government is essentially technical it is recommended that the top technical post be renamed to that of Chief Engineer. This should be held by an experienced Pr Eng or Pr Tech Eng, (registration offered in recognition of competence by the Engineering Council of South Africa (ECSA)) to ensure that sound engineering direction is given and decisions are made. Over and above his or her technical qualifications, experience and professional registration, management training and experience would be a prerequisite for a technical person to assume the most senior post.

Job descriptions

Over the years job descriptions have been reworked on the basis that technical knowledge is not critical for the management of any department. They have thus become a cacophony of management duties and generally exclude the technical expertise so vital to manage infrastructure processes and service providers and ensure that sound technical decisions are made. Job descriptions require a complete rewrite to recognise knowledge, qualifications and the technical experience required per post.

Junior posts

Few municipalities make provision for junior posts. This precludes those on internship contracts with municipalities from being appointed when they graduate. Developmental career paths should be re-introduced allowing junior staff to proceed towards seniority with the attainment of specific competencies. This will offer a clear career path to the employee, allowing him or her to move up in one municipality without the need to job hop, and allowing the municipality to benefit from the ever improving skills.

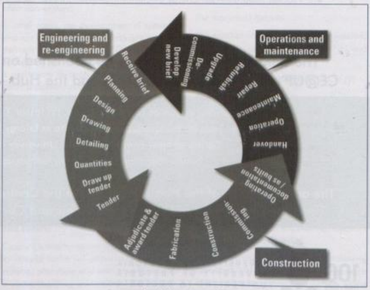


Fig. 3: The project cycle.

Re-develop appropriate organograms

Departments must re-develop their organograms to encompass all technical functions required in local government from chief engineer to labourer. They should also accommodate junior, middle management and senior posts to allow career pathing as discussed above.

A distinct weakness is the lack of operations and maintenance (O&M) staff. The LGSETA (Local Government Sector Education and Training Authority) reports that in many municipalities there are no labourers or elementary workers, and many municipalities complain of having only one or two artisans left. A sampling of artisans in local government carried out in 2006 showed that an additional 1100 water servicemen (municipal plumbers) and 1100 electricians were needed to cope with O&M. On average one third of these posts were vacant, but it was not unusual to find vacancies of 50% and in some instances 100%.

Training

Engineering professionals undergo their tertiary studies at universities and universities of technology and graduate as engineers, technicians or technologists, as shown in Figure 1. A system of workplace training and skills transfer is essential. This demands the availability of experienced supervisors and mentors to support graduates and ensure that they are timeously rotated from one department to another to gain the range of experiences required. Due to the shortage of experienced technical staff in local government, it is critical that retired engineers be harnessed to assist with supervision and skills transfer.

Retention

Retention has become a major challenge worldwide, as the skills shortage becomes more acute. Many inhibitors to retention have been raised, including:

- A frustrating environment where professional judgement is not recognised
- Lack of authority, although technical staff are expected carry the responsibility and be accountable for service delivery
- Excessive bureaucracy and the need to report the same issues to many bodies, each in a different format
- Uncompetitive salaries
- Lack of opportunities and support for developing and retaining professional status
- Contract appointments

There is a desperate need to retain those with knowledge to lead, train, manage service providers and oversee all processes. It is critical that senior job descriptions offer a level of authority and technical departments are once again offered some degree of autonomy. Support staff are needed within technical departments to reduce the bureaucratic burden from those whose technical expertise is so valuable to local government.

When considering salaries and packages, premiums should be paid for tertiary qualifications, professional registration, years of experience in local government and years of service within the municipality. Furthermore professional registration fees should be paid and technical staff should be afforded the opportunity of attending meaningful workshops and courses each year in order to retain their registration through continuing professional development.

Where in-house staff have not been adequately trained towards professional registration, a concerted effort, including the deployment of retired mentors, and rotating staff to allow them to develop the range of competencies required, should be mounted.

The process of appointing on contract must urgently be reviewed. Currently, on expiry of these contracts, staff must reapply for posts. This is a long and uncertain process. As a result staff start looking around and find alternative employment before they are finally notified that they have been reappointed. The decision whether to end a contract should be transparent and include parameters such as past performance, continued need for the specific skills etc. Such reviews should be carried out at least six months before the expiry of the contract. Longer contracts should also be considered.

Attraction

It is essential that technical expertise and competencies be developed and/or attracted, recognised and utilised. As soon as steps are put in place to allow municipal staff to progress in their careers and use their skills to lead development, local government will again become a career of choice.

When carrying out research in 2005, it was found that students studying civil engineering came only from a portion of the country. There were no students studying from many municipalities, which means that these municipalities will be unable to attract civil engineering professionals wishing to return home in the future.

Career guidance, awarding of bursaries, offering experiential, workplace and in-house training should form the basis of training policies to ensure that more young people are attracted into and developed in the sector. Furthermore, meaningful organograms and job descriptions, career progression, more autonomy and authority for delivery departments, and uncoupling the business of local government from the politics of local government must be addressed in order to attract those with experience back into the sector.

The barriers associated with employment equity must also be dismantled to ensure that experienced staff can be appointed. Setting targets in relation to race and gender with respect to availability and experience per age group would be more sensible.

With these issues addressed, a concerted rebranding campaign will be required before appropriate applicants would even consider responding to local government adverts!

Creating an enabling environment

Many institutional issues have been discussed. Of importance is the need to remove frustrations and bottlenecks to the delivery process. The most important of these relate to supply chain, HR, the demand for reports when systems and processes are not in place, and the lack of authority.

Supply chain

The arduous process of making purchases and appointing service providers is well known. The three-level decision-making process represented by the bid, adjudication and awards committees presents challenges all the way in terms of skills, cooperation and interference. Municipalities that have been successful have done some or all of the following:

- Transferred the maximum value of delegation to the Executive Director of Infrastructure Services (R10-million is allowed)
- Appointed service providers using contracts in place with other organs of state
- Developed service provider rosters – this is acceptable within the supply chain regulations based on competences required
- Set time limits per stage of the process, linked these dates to the project programme and made a person responsible for ensuring that there are no delays
- Developed standard specifications for particular groups of projects
- Grouped similar projects into one tender
- Ensured the Supply Chain Committees are properly constituted with appropriately qualified staff, including staff from the department requiring the product or service
- Used the turnkey model whereby the contractor appoints the consultant, cutting out one complete tender cycle
- Used sole-service provider contracts where specific products are critical to performance

- In the case of bulk services to be funded by developers, municipalities have not insisted on the bulk contributions being paid into their coffers, but have commissioned developers to develop bulk infrastructure themselves, according to the municipality's specifications and levels of service standards

Human Resources (HR)

The human resource (HR) process, including decision making, has been totally removed from individual technical departments. As a result new employees are generally not selected by those who will be employing or managing them. This disconnect between the employer and those handling the process results in delays and inappropriately qualified or inexperienced staff being appointed in many cases. It is essential that the screening, selection and appointment process reverts to technical departments and HR simply offer the support of advertising, setting up interviews and finalising contracts. Any interview panel should include professionally registered peer(s) or/and supervisor(s) relating to the position.

Reporting systems

The need to report to many bodies on the same issues in many formats is extremely time consuming and frustrating to those involved. The absence of systems makes such reporting particularly difficult. Simplistic, online, real-time reporting on a select number of KPIs should be all that is required to ensure progress.

Network management systems, stores control systems, town planning and building plan approval systems, to name but a few, should also be reinstated to improve the efficiency of technical departments. By having real-time information systems, the reporting burden would be a thing of the past, since reports could be generated as a standard by-product of such systems.

Authority

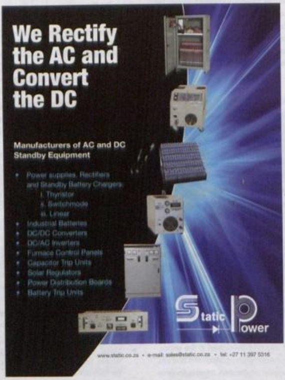
Support departments, while meant to support line departments, have usurped the authority and undermine the processes which are the domain of technical departments. A review of the corporate services model is urgently required.

The need for turnaround strategies

Turnaround strategies need to be developed. Master plans must be updated or developed from scratch, and long-term, holistic views and budgets must be integrated into IDPs to turn them into credible documents. The difference between an IDP and a departmental business plan must be clearly understood. Budgets must be prioritized with service delivery and sustainability in mind and must be based on value for money and life cycle costing.

Organograms must be developed to suit the actual needs of departments, and staff must be appointed and offered workplace training. Career pathing and direction must be given to each employee. Lost data must be located. Systems and operating procedures must be developed, including those related to HR and procurement. Losses must be addressed and appropriate performance must be driven at every level.

Classical management theory advocates the need for dedicated staff to manage such turnaround processes. Experienced, possibly retired staff should be considered. They should work directly with the municipal manager and existing structures to assess, make recommendations and implement the changes required to bolster technical departments, without disrupting their already delicately balanced day-to-day operations. Once a turnaround plan is agreed it must take precedence in the IDP and Annual Budget.



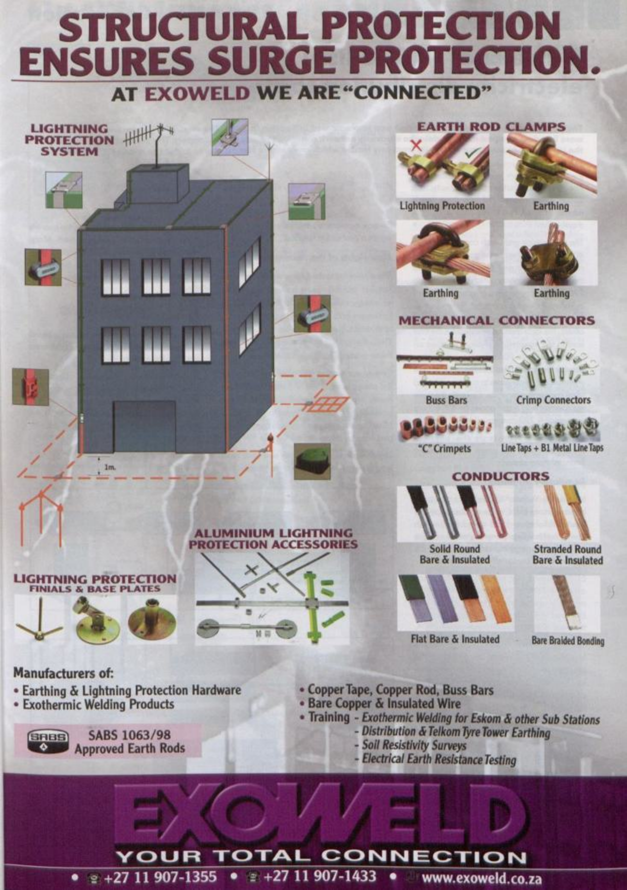
Conclusions

There is a need to re-engineer local government. More than double the existing number of civil engineering professionals are required to address the associated service delivery. Instead of restructuring, structures should be rebuilt. Instead of politicising appointments, they should be professionalised. Professional judgement should be highly valued. Selection based on professional registration and experience is essential. Where suitably qualified people cannot currently be found, retired staff need to be redeployed to offer their expertise until such time as in-house staff have been adequately trained. This could take several years. A self perpetuating system of developing new young professionals to take over when older experienced staff vacate is essential.

Organograms and the competency framework should form the backbone for staff development and should dictate all HR processes such as advertising, selection, recruitment, performance management, talent management, succession planning, career pathing, training, development, reward and remuneration to select and recruit the right people, identify critical development areas, and promote people timeously.

Budgets must be prioritized with service delivery and sustainability in mind and must be based on value for money and life cycle costing.

Systems and processes should be redeveloped and linked with technical competency profiles to ensure that our national assets are adequately developed, operated and maintained.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Lightning Protection
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Gävle Energi (Swedish) electricity distribution tariff

The deregulation of the electricity market was implemented in Sweden in 1996. The electricity generation, sales and trade were listed on an open market while the electricity network continued to stay as a monopoly. This separation gave customers the possibility to purchase electricity from any trader which created the Nordic power exchange market (NordPool).

by Herlita Bobadilla Robles, Gavle Energi

For the transmission of electricity, the network was rearranged into three levels namely: transmission, regional and local distribution.

The transmission grid which consists of 220 to 400 kV lines is owned by the government and is called "the Swedish grid" (Svenska kraftnät) while the regional transmission which consists of 70 to 220 kV lines is owned by a few companies such as Vattenfall (Swedish company), Fortum (Finnish company), EON (German company) and a few others. The local distribution network is the final level in this transmission chain; it operates on a voltage of 0.4 to 70 kV. The local distribution network is owned by various corporations, from multinational corporations to municipalities and small cooperative networks. Currently, there are approximately 175 companies (in 1996 there were roughly 220 companies) in Fig. 1 and 2.

The red line represents the physical transmission and the green lines represent financial transmission.

Regulatory Authority

In order to monitor and regulate the local distribution operators, a new regulator authority was established in 1998 called the Swedish Energy agency (Energymyndigheten) which is currently the energy markets inspectorate (EI) that works for energy efficient markets.

EI developed the network performance assessment model (NPAM) and uses it as the main tool for regulation. The first year that the EI utilized NPAM for monitoring and regulating the local distribution operators was in 2004.

The NPAM determines the revenue that the local distribution operator could obtain in the previous year. This model builds a fictional local network based on a set of conditions determined as a standard cost to operate the fictional network during that year, which include the customers' coordinate locations and energy consumption during the monitored year. And from it, it calculates the correct revenue and takes into consideration the distribution network power quality.

The company's reported revenue divided with that of NPAM's calculated revenue, results in a coefficient called "debiting rate". If the debiting rate is greater than one (1.0) it implies that the distribution operator has overcharged the customer.

Several operators have been instructed to return a part of the revenue.

New rights of the customer

These have led to the Energy act. The new Act requires monthly measurements and reports of energy consumption to be reported to customers and has resulted in an investment of 80 MSEK (just for Gävle Energy customers). This is due to the major investment of automatic meter reading (AMR) to all consumers.

Several companies has gone beyond what the energy act requires and installed AMR for hourly measurements which provides for the possibility of applying different tariffs, which is based on the fuse size for small commercials and even for domestics consumers

The deregulation and all the new laws have lead to ownership changes of the transmission and distributions grid, resulting in the quantity of local grid being compromised. Many municipalities and small distribution grids have sold to new multinational companies which currently operate in Sweden.

Distribution tariff

Introductory comments

The financing of the electricity industry is based on the revenue generated from the customers who buy the services.

The global and national demand of a reliable network with very few interruptions, together with the growth of energy consumption has resulted in an increase of investments by the industry for reliable and robust network with better capacity for transmission of electricity.

The increasing costs of energy and in administration resulting from the new

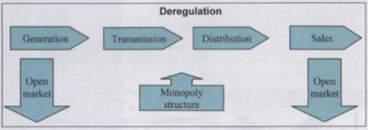


Fig. 1: Deregulation in Sweden.

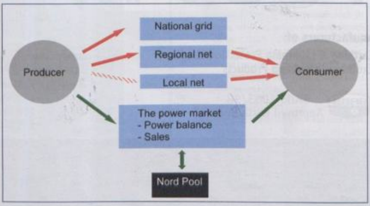


Fig. 2: Structure of the electricity market.

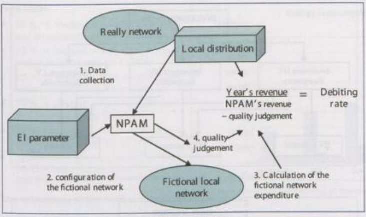


Fig. 3: Principle of the NPAM.

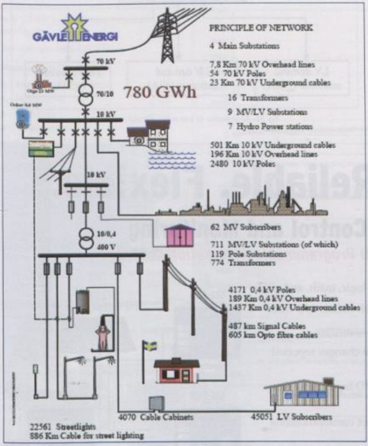


Fig. 4: Principle of the distribution network.

requirements of the energy authority have resulted in a rapid increase of prices in the distribution transfer fees.

Fortunately, the factors which affect the pricing of these services are varied and they can be used with different aims in order to reduce the impact on the electricity industry and on the customers.

Although it is a complicated process to calculate the correct tariff for each customer and electricity network, the idea is to have a reasonable fee for the energy distributed and each customer will only be charged for the amount that he/she consumes. It has to be simple to administer and reasonable on the customer.

At present, the tariffs are generally classified by voltage levels and by fuse size. They are also classified by the nature of the customers' business for example a farmer, commercial businesses, etc.

Other bigger customers such as factories and industries have a tariff based on maximum power demand (kW) which results in an additional invoice at the end of the year. All these classifications add enormous administration work and these extra costs are also covered by the tariff..

Vision for Gävle Energi's tariff

- Economical : To make a profit for the owners of the network and have sufficient for future investment
- Technological : To decrease the electricity usage during high demand
- Administrative : To decrease the administrative management of billing
- Customers: Each customer will only be charged for the actual usage
- Regulator: The income from the tariff has to be below the regulator's requirement

The current tariff of Gävle Energi

The tariff is based on the level of voltage connection, measuring electrical parameters and supply size. There are no special tariffs based on the customers' activities.

The main classification is done on voltage levels: High Level Customers (10 kV) and low level customers (0,4 kV).

High level voltage customers (10 kV) .- they are charged a fixed fee (SEK/year), an unit charge of electricity delivered (ct/kWh), peak demand capacity charge is the average of the three highest peak times of the month (SEK/kW), off

peak demand capacity charge is the average of the three highest for that off peak times for the month (SEK/kW) and charge fee (SEK/kVAr) for the above of the free reactive power level. The free reactive power for those customers is 40% of the active power.

Low level voltage customers (0,4 kV) are subdivided as follows:

- Demand tariff supply from 80 A: is charged a fixed fee (SEK/year), an unit charge of electricity delivered (ct/kWh), peak demand capacity charge is the average of the three highest peak times of the month (SEK/kW), off peak demand capacity charge is the average of the three highest for that off peak times for the month (SEK/kW) and charge fee (SEK/kvar) for the above of the free reactive power level. The free reactive power for this customer is 50% of the active power.
- Demand tariff (63 A): is charged a fixed fee (SEK/year), an unit charge of electricity delivered (ct/kWh), peak demand capacity charge is the average of the three highest peak times of the month (SEK/kW), off peak demand capacity charge is the average of the three highest for that off peak times for the month (SEK/kW).

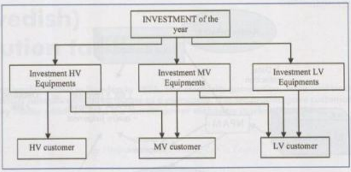


Fig. 5a: Principle for the investment expenditure between the customers.

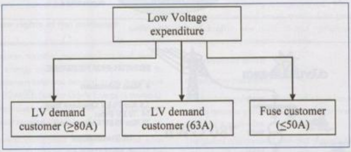
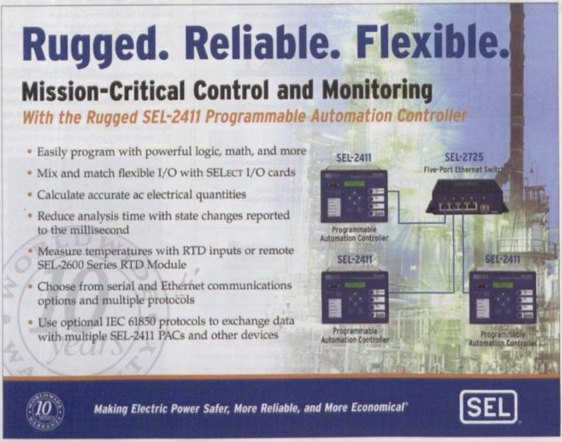


Fig. 5b: Allocation for LV cost to the different categories.



Fuse tariff:

- 50 A - is charged a fixed fee (SEK/year) and an usage charge fee (ct/kWh).
- 35 A- is charged a fixed fee (SEK/year) and an usage charge fee (ct/kWh).
- 25 A - is charged a fixed fee (SEK/year) and an usage charge fee (ct/kWh).
- 20 A- is charged a fixed fee (SEK/year) and an usage charge fee (ct/kWh).
- 16 A- is charged a fixed fee (SEK/year) and an usage charge fee (ct/kWh).
- Apartments tariff - is charged a fixed fee (SEK/year) and an usage charge fee (ct/kWh).

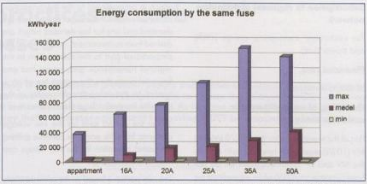


Fig. 6: As per the annual meter reading, an apartment consumes from a few kWh/year to 37 000 kWh/year.

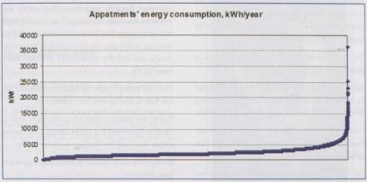


Fig. 7: A house without electrical heating consumes between a few kWh/year to 64 000 kWh/year.

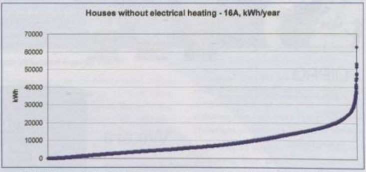


Fig. 8: A house with electrical heating consumes between a few kWh/year to 76 000 kWh/year.

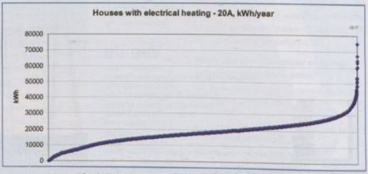


Fig. 9: This is the reason the future tariff will be based on the actual usage of power and not on the fuse size.

The calculation of the tariff

To do a reasonable and impartial tariff calculation, a careful study of every level of the distribution network is made. From the feeding level (70 kV) until the lowest distributed voltage (see Fig. 4).

The costs are divided as follows:

Main cost groups:

- Investment/reinvestment
- Maintenance
- Power loss
- Administration
- Subscription to regional distribution network
- Financial cost

Sub cost groups:

Investment/reinvestment

- Investment/reinvestment high voltage equipment.
- Investment/reinvestment medium voltage equipment.
- Investment/reinvestment low voltage equipment.

Maintenance (similar to investment/reinvestment)

- Maintenance high voltage equipment.
- Maintenance medium voltage equipment.
- Maintenance low voltage equipment.

Power loss

- Power loss in high voltage equipment.
- Power loss in medium voltage equipment.
- Power loss in low voltage equipment.

Administration

- General administration for the company.
- Administration of customers connecting to high voltage.
- Administration of customers connecting to low voltage.
- Administration due to customer segments

Most of the administration expenditure is directly related to a customer group.

Subscription to regional distribution network

For customers' consuming energy (kWh) and power (kW).

Financial cost.

Similar to investment.

Grouping of expenditure per customer category

Part of the expenditure for the HV (70 kV) and MV (10 kV) equipment has to be split among the MV and LV customers (note we do not have customer at 70 kV) while expenditure for LV equipment is only for LV customers.

Power loss costs are similar but initially we calculate the power loss for each voltage-equipment and split it between no load losses and full-load losses.

This allocation principle of expenditure is easy to apply to every cost item.

Adding all these expenditure items would result in the total expenditure per voltage category which needs to be split into the sub categories.

From this level, expenditure resulting from the high voltage customer can be split into different fees.

For GEAB, they are grouped into a fixed fee which is proportional to the administration cost; a fee for the usage power in high demand and one for low demand (which are derived from re-investment, maintenance, the proportional part to the subscription to the regional transmission grid, power loss and financial cost); then the energy fee which is loaded by the proportional quantity of the regional transmission grid and power loss.

To get the correct tariff for the low voltage customer, from this point, we continue splitting the added allocation for the low voltage cost into the sub categories.

This new portion is based on the administration, usage power and energy sub categories consumed. This is similar for the high voltage customer, the difference being that we do not measure the customer usage fuse (supply) tariff but we assume that these customers use 0,9 of the fuse. In this way, we can calculate the power usage and split the expenditure between them (see Fig. 5).

The next step is to split the allocated amount for the fuse customer into their categories.

Here, we assume that all customers with a certain fuse have the same usage and hence share the cost for that amount of power.

Hence, the expenditure is allocated into each fuse category.

The power cost is split into a fixed fee and energy fee.

Future tariff – a reasonable tariff

Since the introduction of the new laws to measure the monthly consumption of customers', a reasonable tariff is available.

The current tariff for customer with a fuse tariff imply that customer with the same fuse has to pay as they use 90% of the fuse irrespective if they use that power or not. So same customer are paying for others consumption and some other who uses the entire potential of the fuse are subsiding by those who do not utilize the whole fuse.

Figs 6 - 9 illustrate the great difference of consumption between customers with the same fuse size.

Conclusion

Our challenge will be to teach our customers the difference between energy and power and how they can manage their energy consumption in an effective way. At the same time we believe that with the new tariff, we can reduce the power peaks and the reinvestment in the current network, simultaneously reducing the subscription cost to the regional transmission grid.

Emerging best practices to curb non-technical losses

Meter equipment tampering and energy theft is a widespread problem. Supply authorities experience losses relating to tampering ranging from 1,25 – 58% of total revenue. The intent of tampering is to reduce the account, without reducing consumption. It is by nature fraudulent. It is an economic and criminal offence. As the cost of energy increases, incidents of tampering and theft will escalate. Energy theft and meter equipment tampering MUST be stopped and perpetrators must be taken to task.

by Claudia Coetzer, Integrity Control Systems

Introduction

Readers of this report may nod their heads in agreement, but why then, are so few doing anything proactive about deterring it? Why is not more emphasis placed on the deterrence of meter tampering and energy theft? Why is there such widespread reluctance to get the basics in place? These questions will hopefully be answered by analyzing field comment extracted through a case study conducted by Integrity Control Systems (ICS). The case study reveals interesting correlations between supply authorities who have disciplined initiatives in place, who use uniquely numbered seals and who have been successful in deterring non-technical losses. The case study also highlights that management commitment precedes the implementation of simple control measures all of which support the success of a dedicated revenue protection program.

No supply authority, on a global scale, is immune to the prevalence of meter tampering and subsequent energy theft. There is a very definite correlation between entities who take a firm stand to reduce their losses by getting the basics right and following four steps:

- Management commitment to addressing the problem – adopt a zero tolerance policy
- Implementing a dedicated revenue protection programme with measurable objectives
- Replacing archaic lead and ferule sealing methods with plastic, tamper indicative, uniquely numbered seals
- A dedication to community awareness, training, education and responsibility transfer

Problem definition

One asks the question: What is at the core of every business? The answer should surely be: Making money to be both profitable and sustainable. Unless supply authorities embrace a zero tolerance attitude towards electricity thieves, energy theft will continue unabated and will keep on eroding the profitability and sustainability of energy distributors. In light of the energy crisis, the active prevention of energy theft has never before demanded such desperate attention.

Situational analysis

There are no non-criminal reasons for meter equipment tampering. Someone wants to consume energy but doesn't want to pay for it. And if he gets away with his endeavours, he is guaranteed to do it again, and again. It is devious but it has to be proven before there is any hope of curbing this behaviour. Having no deterrent mechanisms in place or generic ones (like lead seals or ferules) which anybody can manipulate, find, borrow or buy, plays right into the hands of the person or parties behind this criminal behaviour because the supply authority simply has no reliable recourse for action.

What are the implications of this perpetuated energy theft?

Plunged into a recent energy crisis, it may not be so far fetched to attribute some portion of the energy crisis to the ineffective manner in which energy theft, wasteful usage and non-payment has been handled by policy makers and supply authorities in the past. The implications are far reaching and painful; personally and economically.

I make reference to research recently conducted by Mr. Chris Yelland, managing editor of EE Publishers. In an article published in the April 2008 issue of Energize, he recorded his findings, of which I extract the following: "...the impact of lost revenue of the electricity distribution industry due to theft and unpaid electricity of 12 934 GWh per annum is about R5,34-billion per annum." It should be noted that the non-technical losses are equivalent to the Eskom target saving of 3 GW. Even when the generation capacity problem is solved, the financial shortfall created by energy theft and non-payment will not miraculously go away, it

will simply continue on its perpetuated cycle unless more is done to stop or at least deter meter tampering and associated fraud.

This paper does not profess to uncover the reasons which have led to this mammoth problem situation nor will this paper elaborate on a myriad of solutions to judicial challenges in dealing with energy thieves.

It suffices to say that I have observed reluctance from industry to quantify the scale and monetary value of non-technical losses prevalent in a particular entity, and, perhaps by drawing your attention to the previously mentioned statistics, the matter of meter sealing will deserve a slightly more elevated rank of importance.

What are the objectives of using uniquely numbered seals?

- Restricting access to certain parts of a device (interference, theft, vandalism, safety)
- Deter tampering and to provide reliable proof of tampering
- Identify the point of liability
- A visual checking mechanism to act as an integrity flag: consumer behaviour and equipment status

- The presence of seals validate the quality of a process or work performed
- To validate the calibration of meters to SABS standards
- Ensure the integrity of the initial commissioning
- Ensure process control and traceability from the start of the meter's life cycle
- Create an audit trail of activity associated with that item of metering equipment

Academic definition of a seal

A security seal is a passive, one time locking device, with a unique, serial number, identification or bar-code that is used to provide a reliable indication of tampering (unauthorized removal or attempted removal) or entry. In addition, by virtue of its construction, the security seal provides limited resistance to an intentional, pre-meditated attempt to open it and gain access to the meter or metering equipment that is sealed with the seal. It should not be possible to manipulate and breach a seal without clear visual indication thereof, nor should it be possible to cannibalize a seal to construct another functional seal. Seals require inspection to indicate whether tampering has occurred or entry has been attempted.

A lateral viewpoint:

Interestingly enough, many users of seals, revenue protection officials and industry players conjure very different associations when asked to define a 'seal', but the following colourful definitions have a common thread: it is a control and warning mechanism which creates an audit trail and when breached, should lead to a secondary action.

'The seal says STOP, don't try to get in there', 'The seal draws the line in the sand, it eliminates the grey area', 'A seal is a deterrent to discourage a devious attempt', 'The seal is a watchdog which triggers secondary actions', 'The seal is the 'finger-point' to say YOU DID IT' 'It is a visual warning: if you are in breach, we'll catch you' 'The seal is like a mouse-trap, if its breached, we have proof and can take action.' 'A seal may not stop the entire problem, but it's the vital step to containing the problem', 'A seal is the irrefutable proof that someone is acting fraudulently and which helps us to prosecute or even to just recover our revenue', 'The seal is a visual indicator of the goings on surrounding that piece of metering equipment'.

Findings from a case study conducted by ICS

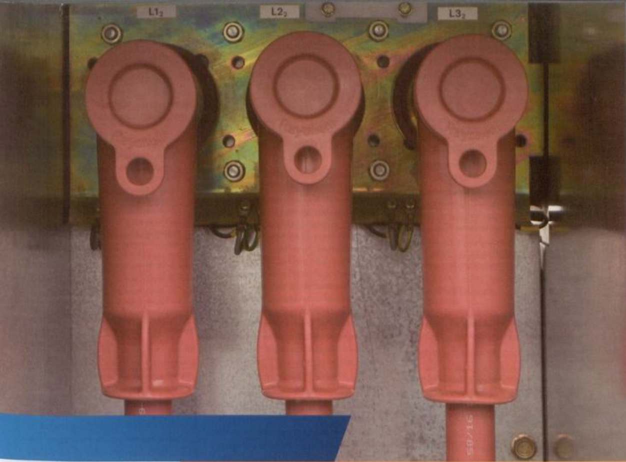
ICS embarked on a case study involving 19 utilities and supply authorities in Southern, Eastern and Central Africa. The research was conducted over a period of 4 months and the responses as at 18 July 2008 indicate the following statistics:

- 100% experience meter equipment tampering and energy theft. The reported percentage of annual revenue loss due to energy theft ranges between 1,25% and 58% of total revenue.
- 100% reported that consumers are most likely to engage in fraudulent activities, in addition.
- 16% reported that their own staff are most likely to engage in fraudulent activities.
- 16% reported that contractors are also likely to engage in fraudulent activities.
- 84% of utilities & supply authorities have dedicated Revenue Protection programmes.
- 37% have formal sealing policies in place to control the use of uniquely numbered seals.
- 91% of users of lead seals & ferules confirm the ineffectiveness of this sealing method.
- 42% are currently utilizing plastic, uniquely numbered seals.
- 100% of users of uniquely numbered seals feel that tampering is deterred more successfully than when using ferules, lead seals or no seals.
- 58% are using uniquely numbered seals (plastic, metal or self adhesive seals).
- 29% of users using uniquely numbered seals, have no or inadequate databases in which unique seal numbers and associated information is recorded.
- 100% feel a seal tracking system would be of benefit (either a simple paper based system or web based).
- 61% feel the current legislation is inadequate in addressing the severity of energy theft.
- 53% place an emphasis on community awareness training and education as part of a successful revenue protection programme.

A quantifiable 'before and after' scenario was difficult to document as many of the entities reviewed have only recently begun transition strategies from using no seals, or lead seals or ferrules, to uniquely numbered seals. It is estimated that measurable improvements would only really be evident after two to five years of dedicated, measured strategy.

The primary conclusion one draws from this research is that supply authorities who utilize lead seals or generic ferrules are more vulnerable to non-technical losses than those supply authorities who have stringent sealing policies in place, coupled to the use of plastic, uniquely numbered seals.

STOP



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The secondary conclusion is that strong leadership and focus in management, underpins the success of any revenue protection endeavour.

Thirdly, community awareness training enhances buy-in and co-operation in terms of energy theft prevention and resource conservation.

Fourthly, the old adage of 'what you can't measure, you can't manage' was echoed. If your data is unavailable or inaccurate, this also needs to be a focal point in any attempt to contain non-technical revenue loss.

Integrity Control Systems has been closely involved in co-operative projects with several of the entities researched and have successfully developed appropriate, practical and cost effective solutions to combating the threat of meter tampering and energy theft.

Reasons cited for the lack of meter sealing and seal control

- No dedicated Revenue Protection initiative
- Ignorance of the problems associated with old, ineffective methods of sealing
- Ignorance of the steps that can be implemented to ensure better management control
- No budget allocated for quality, uniquely numbered seals
- Apathy in implementation of the necessary controls
- Sealing ranks low in importance requiring management focus
- Apathy in people management
- Lack of ownership, whose problem is this anyway?

Has there been any progress?

My observations thus far have been fairly grim, but there is positive feedback, and yes, there is progress. In July 2006, I participated in a panel discussion held at the SARPA convention in Midrand, Johannesburg, entitled: 'What are the benefits of sealing and what are the preferred options." For those of you who did not participate in the discussion and for those who may not recall the outcome, a summary of the outcome is provided. The general response from the forum confirmed the need for seals on conventional meters as well as pre-payment meters. The advantages of using plastic or paper, uniquely numbered seals, in various colours, seemed widely and favourably acknowledged. Although still in use, the weaknesses of lead seals, ferrules and wire, received knowing nods from the forum. The biggest, two-pronged question raised from this discussion was; will SARPA and a working group, work towards the setting of a sealing standard to benefit the industry and what is being done to help develop a system which will assist users in the control of the above mentioned seals. Responses to this question will follow.

The positive feedback is that a working group was formed, championed by SARPA and the subsequent result is the publishing of NRS 096 Part 1: The sealing of electricity meters.

A summary of NRS 096: Sealing standard for electricity metering equipment

The purpose of this NRS specification is to establish and promote uniform requirements for application in the South African electricity distribution industry. It identifies available sealing options and sets out guidelines to enhance controls within a revenue protection process. No formalised direction and guidance on the matter of meter equipment sealing, has previously existed which probably contributes to the resulting ignorance about sealing. The standard provides answers to widespread requests for a 'how-to' guideline to manage an effective revenue protection process by implementing simple sealing protocols to create a chain of custody and to ensure its integrity. Subsequent to the request raised at the SARPA convention in 2006, this guideline has been developed and published. NRS 096 supports the NRS 055 – code of practice for revenue protection.

To summarise the main points of this specification:

- The document sets out the requirements for sealing of electricity meters and related ancillary metering equipment
- The document provides guidelines on the roles and responsibilities related to the management of seals, the process for the management of seals and provides information on the requirements for various types of seals
- The primary objective of sealing any item of metering equipment, is to ensure that access to certain sensitive parts of that device is restricted. This is especially so where energy meters is concerned, since these form the basis from which revenue is obtained by the electricity supply utility. It is therefore imperative that strict sealing standards are established and that proper control is maintained to ensure that these requirements are adhered to
- A secondary objective of sealing is to provide a mechanism by which the last person to have worked on a specific piece of equipment can be traced – a reliable audit trail.
- The document details the steps in implementing an effective sealing policy. These include:
  - authorised management and control of seals;
  - authorised procurement from a compliant supplier;
  - receiving of seals;
  - secure storage;
  - authorised issuing;
  - staff training;
  - auditing of seals;
  - returned seals;
  - accurate record keeping and info transfer onto secure database;
  - seal disposal
- The document explores various sealing options available to the industry. A strong rejection of lead seals is voiced and hopefully everybody to whom this paper is directed, is aware of the harmful properties of lead. Metal seals are not recommended due to the corrosion factor and high vulnerability to tampering. The document does make allowance for paper seals, otherwise known as security labels and copper ferrules and wire, but strongly promotes the use of uniquely numbered, plastic seals.
- The document proposes a colour code for tool-less seals to identify various tasks performed on the metering equipment.

The over sight

Although the creation of the NRS 096 is an extremely positive development which has given the industry a much needed tool to enhance their revenue protection endeavours, it is not mandatory. In light of the staggering statistics highlighted earlier in this paper, it concerns me that this standard cannot be formally imposed on the management of supply authorities who should be directly accountable for the prevention and deterrence of energy theft.

The use of generic, un-numbered ferrules is still widespread amongst municipalities and Eskom as a whole. This archaic method of so-called sealing creates a false sense of security and control as there is nothing to audit and monitor, yet, this method of sealing is included in the NRS 096 as an 'acceptable' means of sealing. Comments from the field are frequently received stating that users do indeed have 'uniquely' numbered pliers used to crimp lead seals and ferrules. Let us for a moment define the word 'unique' – one of its kind. This may be so for the crimping tool or pliers, with personalized jaws, but as soon as more than one lead seal or ferrule is applied to any item of metering equipment, the controls are diluted and one essentially cannot differentiate one sealing activity from another. There is no longer a singular, unique seal, which creates an audit trail - every seal looks the same in that application chain. If a lead seal or ferrule is intact on visual inspection, is it really intact, or does the possibility exist that it has been breached and simply been replaced by another one, using the same pliers or crimping tool? The same risk applies to the pliers getting into the wrong hands or being lost, there is no subsequent control of this tool which simply does not distinguish one sealing action from another. One cannot realistically expect a deterrence value from something that is easily manipulated and easily available to replace to disguise criminal behaviour. A reluctance to change is clearly evident. Perhaps the numbers that are coming out of the research and case studies will shake up the industry and will advocate the necessity to rule out lead seals and ferrules, recognizing them for what they are: outdated, inadequate and simply put, a waste of time, money and resource to apply them. Provision should be made to replace these dinosaurs with uniquely numbered, tool-less seals.

Numbering format: a matter that remains unaddressed

To reiterate, NRS 096 has been a very worthwhile basic step in compiling a guide line to the industry on sealing options and the implementation of sealing control protocols. If viewed in isolation as an initial step, it has achieved its objective. However, as a supplier to the industry, it has been noted that the validity and integrity of numbering formats for seals, calls for a little clarity.

This issue was not explored during the development discussions of NRS 096 and may not perturb users too much at this stage, who are still in the transition phase; no seals or lead seals/ferrules to uniquely numbered seals, but, it could raise complex problems at a later stage. It may be necessary to propose an addendum to the NRS 096 as it currently stands to include a minimum quality and security standard for seals. Discussion needs to focus on a conformance with number sequence formats across multiple suppliers which will ensure the integrity of a supply chain of seals into the field and which will help to deter and detect the presence of 'alien' seals in the industry. Integrity Control Systems has identified these challenges and proposes an application guide to enhance the adoption of these guidelines, should they be formalised and to help convert an academic document to practical and manageable implementation.

It is suggested that a numbering format or number allocation standard is developed. This format needs to cater for multiple suppliers and seal types. The number allocation standard is expected to address the transition challenges as identified and is conceptualised to preserve the integrity of the supply chain in supporting the chain of custody throughout the life-cycle of the seal.

Suggested numbering formats:

Format 'A' (accessories): Stock print on seals + 7 digit human-readable number only.

Example: *'SEALED 1234567'*

Format 'B' (bar-code): Supplier ID (AB)/User ID (CD)+ bar-code representing a 6 digit unique serialized code, (alpha & numeric). *Example:*

ABCD Z12345

Format 'C' (compact/personalised): Supplier ID (AB)/User ID (CD)+ 6 or 7 digit unique human-readable number. *Example:*

ABCD Z12345

It is suggested that these numbering formats are applied as appropriate to the application. Seal manufacturers could then innovate and cost reduce various seal technologies as different "types" with a clear understanding of the format of the numbering to be applied.

Format 'A' seals would consist of a 7 digit, human readable number only, and would be recommended for accessories and general, less stringently audited applications. *Format 'B'* seals would be recommended for stringently audited applications embracing bar-coding technology. *Format 'C'* would be for primary use, compact seals (i.e. meter manufacturers). Formats B and C would require that both parties (AB and CD) maintain and retain records of the seals issued. This would help overcome fraudulent and/or inadvertent "loss" of records of the seals issued. Registration as an AB or CD would require proof that adequate capability exists to capture and retain records of the seals issued. A requirement for issue of Format B seals would be an undertaking that CD has understood the field scanning equipment requirements and methods of transferring such information to a secure storage medium. The use of *Formats B and C* would indicate that the user understands his/her responsibility for having adequate controls in place to support the 'chain-of-custody' surrounding seals.

In practical terms, this numbering format would cater for users who have advanced technological platforms in place but will also offer inclusion to other users who wish to comply with the standards proposed but who are still operating manual processes.

The alpha in the number sequence for *Format B and C*, allows 26 additional numbering combinations. If the colour of the seal will be varied and this needs to be recorded, it would be acceptable for the colour of *Format A* and *C* seals to be captured manually. The barcode on *Format B* seals could be specified to contain a field that identifies the seal colour, so that it is captured automatically. The barcode definition thus needs to clarified to confirm the order of the fields (e.g. X for colour, ABCD Z12345)

A comparison between the financial impact of tampering and theft vs. the estimated solution spend

5 supply authorities have been identified to create this scenario analysis.

We reviewed their individual annual revenue, totaled their number of customers, showed the monetary value of their non-technical losses per annum in Rands and used a unit cost of R3,50 for a premium quality uniquely numbered plastic seal. We then calculated the total cost of the uniquely numbered plastic seals to cover the customer profile, basing our calculation on two seals per meter. We subsequently calculated the monetary value of the potential savings if 70% of the revenue attributed to non-technical losses and theft was recovered.

Many acknowledge the existence and impact of the problem, but struggle to quantify it and struggle with the challenge of the lack of resource and capability. If a revenue protection team cannot be mobilized internally, I urge you then to develop a loss reduction strategy which involves the services of an outsourced consultancy. Make them accountable for the measurable results. This service comes at a cost but they are invariably better equipped to manage projects like these as revenue improvement and revenue turnaround strategies are a core competency.

Departure point

The reality and magnitude of the problem has to acknowledged. Management need to take ownership to address the issue of meter tampering. It is recommended that a Revenue Protection Programme is established and NRS 055 provides a comprehensive reference for this. Thereafter a Sealing Policy needs to be formalized, NRS 096 offers guidance in this regard. Hand in hand with these guidelines, a tool kit has been compiled to assist in the practical implementation of an effective seal management strategy.

Tool kit

- Quantify the risk and identify priority areas for seal implementation roll-out
- Assess risk profile (low/medium/high)
- Allocate time frame for roll-out
- Choose appropriate seal (risk, conditions, functionality, industry preference)
- Obtain specifications from supplier
- Standardise seals to be used
- Agree on name, colour/s, numbering format
- Quantity requirements

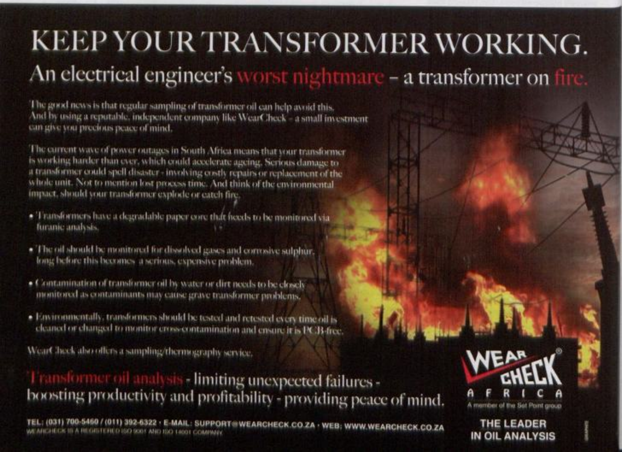
- Procurement process (initial/ongoing)
- User training
- Customer awareness and responsibility transfer
- Web based seal management system or manual control process
- Manage the strategy internally or appoint suitable consultancy
- Define measurement indicators
- Review the benefit of the sealing strategy over a period of time

Conclusion

No supply authority, on a global scale, is immune to the prevalence of meter tampering and subsequent energy theft. There is a very definite correlation between entities who take a firm stand to reduce their losses by getting the basics right and following four steps:

- Management commitment to addressing the problem – adopt a zero tolerance policy
- Implementing a dedicated revenue protection programme with measurable objectives
- Replacing archaic lead and ferrule sealing methods with plastic, tamper indicative, uniquely numbered seals
- A dedication to community awareness, training, education and responsibility transfer

This is a call for engineering managers and revenue protection officials to take ownership for this seriously debilitating problem, to delegate responsibility to do something about it and to set measurable goals to achieve a percentage of non-technical loss reduction over a certain time frame. It is a mindset change. How much more severe must the energy crisis become before more industry members draw a line in the sand and acknowledge the need to act. Little steps to institute control and to demonstrate zero tolerance, coupled with the implementation of an inexpensive, uniquely numbered 'watchdog' will result in substantial financial recovery and will send out the message that criminal acts will not go undetected and without consequence. The time frame in which these case studies were conducted was short and disappointingly, many entities failed to respond even after agreeing to participate. We look forward to continuing the research and to report back on field progress in a future forum.



Regulatory imperatives to stimulate competition and market entry

The paper is based on the hypothesis that more competition and market flexibility is necessary in the SA market to meet the country's energy needs till at least 2013. The paper commences with a brief introduction to the current shortage as a deviation from the requirements and structure set in the Energy White Paper of 1998. It touches on the different options available to move towards market flexibility, like reference to the single buyer purchaser model and multi purchaser model with relation to their regulatory requirements.

by A J van der Merwe

Some practises, statistics and organisational arrangements in Sub-Saharan Africa with regard to regulation referred to and based on specific Tanzanian experience, make reference to important elements in the energy value chain of generation mix, market entry, cost and risk.

The paper also gives some modelling examples to indicate how IPPs can share in supporting the available generation and what kind of recovery plans need to be in place to ensure long term sustainability.

The paper concludes with a list of imperatives drawn from experience elsewhere in Africa and compares the regulatory changes required to ensure market initiatives to stimulate the ESI in SA.

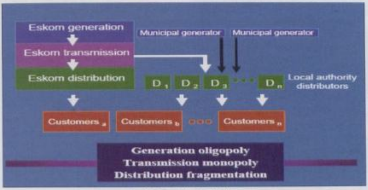


Fig. 1: Current ESI in South Africa.

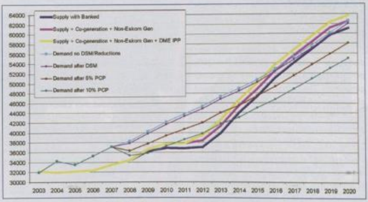


Fig. 2: Supply/demand capacity balance (MW).

Introduction

Background

South Africa has experienced strong economic growth over the past several years. This growth, measured in gross domestic product (GDP) terms, has averaged 4-5% per year. However, continued economic growth is dependent on reliable electrical infrastructure amongst other important requirements. South Africa has recently seen its electricity infrastructure stretched beyond its means in some areas. This threatens to derail the economic growth and South Africa needs to act quickly to avoid enduring negative impacts. The country is instituting a number of supply, demand and infrastructure initiatives to help sustain the integrity of its electricity infrastructure and the possible incorporation of a new market structure. It is essential to these initiatives to structure the regulatory environments in such a way to stimulate access and market entry for new participants.

Current structures

Eskom is vertically structured and responsible for generation and transmission of electricity, and supplies to about 40% by number and 60% by energy, of all end customers. The rest of the end customers in SA are supplied by some 187 licensed municipalities. Although in general in can be said that generation is an oligopoly, due to Eskom's strong dominance it is more a monopoly in both generation and transmission. These relationships are shown in Fig. 1.

Power shortage

Eskom envisage a shortage in capacity due to the fact that the generation reserve margin has been depleted. The graph in Fig. 2 illustrates this situation.

The question then arises as to what kind of structure and regulatory initiatives will provide the necessary incentives to ensure adequate supplies for the economic growth targets envisaged by government?

Government's energy sector policy's and approach on IPP's - governance issues

Background on Independent power producers

The Energy White Paper (EWP) of 1998 clearly stipulates government's intention regarding the introduction of Independent Power Producers (IPP's) in the South African electricity market. The original idea was that government will encourage competition within energy markets and will adjust electricity market structures to achieve effective forms of competition. Supplies would be secured through diversity by:

- Introducing competition into the industry, especially the generation sector
- Permitting open, non-discriminatory access to the transmission system
- Government initiating a comprehensive study on future market structures for the South African electricity supply industry
- The introduction of independent power producers (IPP) in the South African electricity market
- Mechanisms to ensure that equity and environmental goals are achieved, and possibly even accelerated, throughout the market restructuring process and thereafter

Further to the above, Cabinet in 2003 approved private-sector participation in the electricity industry and decided that future power generation capacity will be divided between Eskom (70%) and independent power producers, or IPPs (30%). The Department of Minerals and Energy (DME) was mandated to ensure private-sector participation in power generation, through a competitive bidding process, and that diversified primary energy sources are developed within the electricity sector without hindrance.

A power generation investment plan was drawn up to take into account this 30% private-sector participation in power generation. The planning and development of transmission systems would be undertaken by the transmission company, subject to the government's policy guidelines.

During 2003, Eskom implemented a revised business model to prepare for capacity requirements and the impending restructuring by splitting its business into regulated and non-regulated divisions. Eskom's core business, its strategic support businesses, and target markets were reviewed and agreed on.

The approach was that the generation division of Eskom would continue to be part of Eskom. In 2003, the power stations in the division were paired together to form clusters to prepare the generation sector for flexibility to accommodate different options in a changing electricity supply industry (ESI).

The transmission division would then take responsibility for the electricity grid. Worldwide transmission is a natural monopoly. In South Africa, an efficient grid operator needs to be established that will grant all players access to the grid. For example, customers could buy from sources other than Eskom, such as the Southern African Development Community (SADC) electricity pool or IPPs, but still use the same transmission infrastructure to have power delivered to them (The principle of wheeling through the Eskom power network).

What has changed in terms of the governments approach?

Government decided to re-think its policy position regarding competitive electricity markets following events around the world affecting the electricity industry, the California Crisis (2001), the black out in North America and Western Europe(2004), Enron (2002) etc. All of these events suggested that the state has to put security of supply above all and above competition.

In line with the government strategy to reduce the cost of doing business in South Africa, government focused on improving the governance of the electricity sector.

This was done through the development of the electricity regulation regime and by modernising the existing Electricity Act. The vision is that the new legislation will create an enabling environment for new Independent Power Producers (IPPs) and improve governance of the electricity suppliers. The DME is the department responsible to take the initiative to drive the above processes.

The structure that was envisaged is depicted in Fig. 3.

Single Buyer Model for SA – current approach

The current stance of government as far as IPP's are concerned, can be summarised in the following points:

- Cabinet decided that Eskom will be the single buyer of all the power produced by IPP's. Eskom will buy the capacity from the IPP and the latter will be the seller. After the distribution restructuring and the formation of the six RED's the situation for trading in South Africa will be as depicted in Fig. 3.
- The terms and conditions of the PPA will be typically 15 years with an option for extension. Eskom has put out several tenders for co-generation and MTPPP. Baseload and renewable energy is expected to follow in 2009. It is anticipated that Eskom will call on the IPP for plant availability and the IPP would have to make plant available to contribute into the Eskom energy pool.
- The parties to the transmission agreement will be Eskom and the IPP and such a transmission agreement will comprise of the following:
  - Connection agreement dealing with Eskom's obligations to design and construct the interconnection of the IPP and the payment of the connection charges by the IPP;
  - Operating agreement dealing with the requirements of operation as set out in the Grid Code and
  - System agreements dealing with payments that will be impose on the IPP for the availability of the transmission system and the use thereof and rights of access.
- However, there is a general consensus that the single buyer model is only applicable to large scale IPPs. (How large was not stated as the mechanisms referred is not completed as yet) An example was quoted during presentations by the DME, that nothing would stop for instance a municipality to buy electricity directly from the Darling Wind Farm. This opens the possibility for selling to local communities, industries via the distribution system.
- The DME position is that the procuring entity for this energy must be separated from the other operations of Eskom. Currently the mechanisms has not been developed this for.

NER 2002 guidelines

NER produced in 2002 some guidelines to

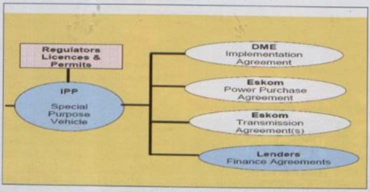


Fig. 3: Current governance stance.

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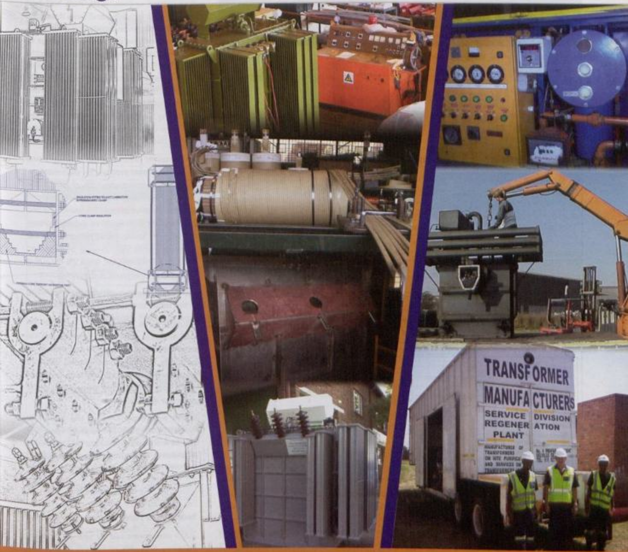

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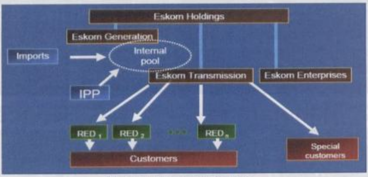

Fig. 4: Limited energy trading in South Africa.

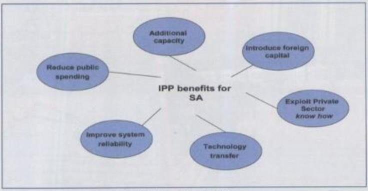

Fig. 5: IPP benefits for South Africa.

	Country / Owner	Economic outlook	Electricity Regulation	Political drive to expand energy sector	Energy growth potential	Potential for viable projects	Support for open market access	Govt Integrated Development Plans
		3	3	1	2	3	2	1
		Rating per criteria per country (5-very good, 4-good, 3-average, 2-poor, 1-very poor)						
1	Angola	4	1	3	5	3	1	1
2	Burundi	1	1	1	3	1	2	1
3	Cote d'Ivoire	2	1	3	3	3	1	2
4	Ethiopia	2	3	5	4	4	2	4
5	Kenya	4	3	4	4	5	5	4
6	Lesotho	3	3	4	2	4	4	3
7	Malawi	3	3	3	4	2	3	3
8	Mozambique	4	3	4	4	4	4	3
9	Rwanda	2	2	3	4	3	3	3
10	Senegal	3	4	5	3	4	5	5
11	Swaziland	2	1	3	3	3	1	3
12	Tanzania	3	2	2	3	3	2	3
13	Uganda	3	4	5	4	5	5	4
14	Zambia	3	3	4	4	5	4	3

Table 1: Qualitative comparison between some SSA countries.

support the establishment of IPPs along the initial thinking. Amongst others the emphasis at the time was to bring benefits as per Fig. 4. The main emphasis would have been to:

- Encourage the participation of the IPP in the power market
- Ensure that an open and non-discriminative access to the transmission and distribution networks is available to all industry participants;
- Provide fair and transparent pricing structures for access and use of the transmission and distribution network;
- Ensure market certainty and transparency required by private investors;
- Promote fair and transparent electricity prices for the customers;
- Promote high level of reliability and quality of the supply;
- Support renewable and environmentally friendly technologies and diversified resources
- Provide a regulatory process that ensures commercial viability and economies of scale for the industry participants

New guidelines have not yet been developed and published.

Lessons from Sub-Sahara Africa (SSA)

Regulatory arrangements

As of 2006, more than 80% of SSA countries had enacted a power sector reform law, 75% had experienced private participation in power, about 66% had corporatized their state-owned utilities, more than half had established a regulator, and more than one-third had independent power producers. But few countries have adopted the full range of reform measures. Moreover, reform programs typically followed an orthodoxy that aimed at creating competition among private electricity suppliers, but few energy markets in SSA are large enough to support the multiple suppliers needed for a competitive environment. Power pools are the only option to introduce some competition.

To redress its chronic power shortages and make reasonable progress on electrification, SSA needs to invest about 3% of GDP in the power sector, mainly to generation assets, and allocate a similar amount for operations and maintenance. Both would be a sharp increase from current levels. Public investment in the power sector in SSA currently averages no more than 0,7% of GDP, while 2% of GDP is allocated to operations and maintenance.

Table 1 provides a qualitative understanding of the status quo in some countries in SSA.

It supports the survey by the IMF that the total market in many of the countries are too small for proper competition and even if the prospects for new market entries(IPPs) are good merely by introducing such a market alone does not solve the power woes of the particular country.

In the own experience of the author in Tanzania during 2005/6 various imperatives can be identified as issues to be attended to in ensuring IPPs contributing successfully to the total need of the energy sector.

These issues will be highlighted in the following sections.

Tanzania and Eastern Africa

2005 was earmarked by one of the most crippling droughts in Eastern Africa. The cluster of countries namely Uganda, Tanzania and Kenya depending heavily on hydro as a generating source were all severely affected and had to revert to load shedding and expensive other thermal generation like diesel and rental plants. To further aggregate the situation global warming caused in general a higher that normal demand on available manufacturing resources causing sharp cost rises in energy outputs. The cost

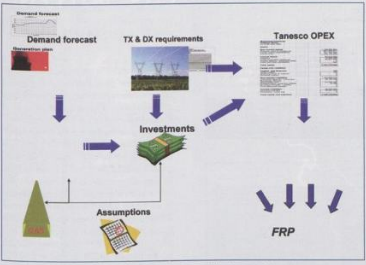

Fig. 6: Structure of business economic modelling for financial recovery.

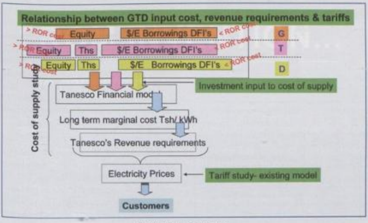

Fig. 7: Investment structure.

of IPP generation versus owns generation funded differently became a real bone of contention as new entrants to the market become essential to prop up the demand requirements. It soon became clear that the cost of unserved energy and the detrimental effect on the economy had to be balanced against old generation investments often grant funded or supported by lower cost of capital arrangements.

It was soon clear that complex sustainability analysis was required to match growing (and suppressed) demand with the changing generation mix- many now from both permanent and temporary IPPs. In normal utility practise revenue became severely affected during load shedding whilst operational expenses often increased sharply with detrimental affect to the GDP. In order to combat these complex phenomena utility scenario modelling was performed to ensure utility sustainability by focussing on the right issues. The model consisted of various modules modelling utility requirements as reflected in Fig. 6.

Investment options

The Tanzania example was based on borrowing working (and some investment) capital to pay short term operating debt and expand the utility business. A delicate balance between equity and debt were constructed based on a Capex master plan for generation, transmission and distribution. This eventually was modeled in several tariff scenarios for the regulator.

However to understand the funding requirements against the utility's needs to ensure sustainability various scenarios for the generation options were built and long term marginal cost of generation was calculated after the improvements of the financial recovery and sustainability master plan has kicked in. The generation mix is shown in Table 2 and Fig. 8, with the resulting LRMC shown in Fig. 9.

Summary

Many African countries endeavour to structure their regulation and markets in a way to encourage IPP participation. Having a market and regulation alone does not guarantee adequate power supplies. From the Tanesco experience several lessons came to the fore:

- A well planned generation mix is essential to hedge against droughts, rising oil prices and coal supplies(and other thermal fuel sources),
- Long term capacity planning and supporting revenues,
- Market transparency of long run marginal cost for IPPs,
- Non discriminatory market entry rules for IPP's and
- Ringfenced costs between national system requirement and those of IPPs

Imperatives for SA's power future

Current status

As described in this paper, the current model in SA is that of a single buyer and as such do not provide readily open access to independent participants in the market. If the model is to be fully utilised it implies that the principle of willing seller and willing buyer is applicable and, if the generation is structured this way, should provide no real impediment to sell the energy generated. However if the regulatory rules are not set clear to be enablers, one would not readily expect investments in

Generation Contribution	2002	2003	2004	2005	2006	2007	2008	2009	2010
Hydro	93,39%	80,08%	59,05%	48,73%	30,11%	31,43%	24,13%	21,15%	19,52%
Thermal Fuel	6,61%	19,92%	30,30%	19,73%	23,49%	10,96%	3,01%	2,52%	2,46%
Thermal Gas	0,00%	0,00%	10,65%	31,54%	46,40%	57,62%	53,45%	53,67%	57,11%
Thermal Coal	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	19,40%	22,67%	20,91%

Table 2: Generation mix.

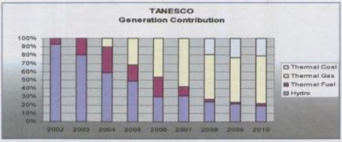

Fig. 8: Tanesco generation mix 2006.

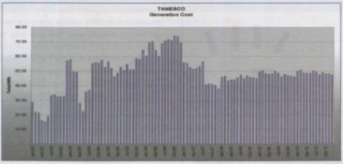

Fig. 9: Tanesco long run marginal cost predictions.

Item	Eskom	IPP
1	Eskom is allowed to pass through the cost of power purchases & power construction costs	Normally not in the ambient of new IPP's to have this luxury
2	Eskom is afforded a return on work under construction (WUC) to ensure smoother price increases. Have a supply base of 95% of SA customers	This is not possible for independent power producers who do not have a customer base in South Africa. This implies that the selling price of an IPP plant will be higher than the selling price of an Eskom plant. IPP plant carries a greater up front risk which would demand a greater return than an Eskom plant (see Darling Windfarm & City Power Kelvin agreements)
3	Eskom is allowed to recover a certain amount of research and development cost and the cost of feasibility studies through its tariffs	A new entrant does not have this source of funding. A small developer may not have the cash flow to develop a proposal up to financial closure
4	The networks where Eskom generators connect are invariably owned by Eskom Transmission or Eskom Distribution	Non Eskom generator is required to enter into power wheeling agreements with network owners. Terms and conditions may be different
5	If connection is not to a local municipality network, Eskom owns network and determines cost of connection of entry	The generator has to negotiate a network connection agreement. The Eskom cost of entry is absorbed between the 95% customer base in SA.

Table 3: Regulatory issues to be addressed to ensure transparency.

the SA market. To make matters worse if the single buyer is not independent but a direct competitor in a market where cost transparencies are not shown, the willingness of buyer and seller becomes a conundrum. (Some of these cost issues are depicted in Table 4 and require careful consideration)

As far as embedded generation is concerned the principle was adopted in the EDI restructuring blueprint that embedded generation of municipalities will remain with the distribution companies up to a certain size. Several generators that are generally known as co- generation (like Sasol) are also in operation in the energy market, primarily as dedicated generation sources. The advantage of embedded generation in the SA context is that no grid access and wheeling arrangements are required and the IPP can make direct arrangements with the off-taker. The purchaser should not be Eskom, but an independent mine, industry or community. Such possibilities become attractive when PPA(s) are entered into between the IPP and specific off takers- especially if the wheeling does take place via the distribution network and not via the transmission system. Feasibility only depends on the price levels in the PPA arrangements with the off taker.

IPPs in SA

It is evident that IPPs are needed in the South African power generation sector to augment Eskom's capacity in meeting the growing energy demand. Eskom is currently embarking on a R150-billion infrastructure roll-out programme. However given the fact that the current Eskom cost is in the order of 13c/kWh and new participants will be in the order of 25c/kWh (2007 figures by DME), true commercial basis for entry will probably not be introduced in the market in the immediate future and according to the Eskom roll out programme not before 2009/10. However the latest results from NERSA Eskom price application indicated a price of 25,5c/kWh for 2008/9, an increase of 27,2% on the already 14,2% granted in 2007/8. With this drastic increase in tariff levels IPPs will become more competitive in future.

It will be possible for a generator (IPP) to apply for a license from NERSA and under the conditions of the license generate. A PPA needs to be entered into with an off-taker and if this power is injected into the national grid, Eskom would be the buyer and an agreement with transmission will have to be found to wheel the power. If it is an embedded generation (per definition directly coupled to the distribution system) with a dedicated off taker, it appears that such requirements would not be necessary.

With the participation of IPPs in the power generation sector, Eskom will have an opportunity to pass some of its risks to the private sector (IPPs). With the generation shortage that will most probably increase over time to yield even a lower reserve margin (only 13% in 2012 is expected), pressure will rise and the generation cost of Eskom will rise dramatically, producing exceptional opportunities to become competitive in the market. It also have to be borne in mind that the current cost of unserved energy is much higher than the cost of served energy and a case could be made that entry in the market or utilising other means is essential.

The IPPs are the only vehicles at the disposal of government to ensure meaningful BEE participation with regard to equity ownership in the power generation sector. It can be expected that government will favourably consider such approaches.

Regulatory Requirements

Due to the vertical monopolistic nature of the market with generation overwhelming the responsibility of Eskom, several cost issues require to a lesser or greater extent some ring fencing to allow non discriminatory market entry for IPPs (Table 3). It is argued that these issues would give an unfair advantage to Eskom and could hinder market participation.

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Item	Cost requirements and other advantages for fair access
1	DUOS cost is currently covered 100% from end loads and should not be payable by the IPP
2	Tx of system cost(fixed amount per annum) is recovered 50/50 between generation and end loads as per the WEPS- should not again be payable by IPP's.
3	The embedded generator's output reduces the power input to the local load area. Would reduce the Tx and some Dx local network losses when generating.
4	Embedded generation gives advantage to add some energy requirement instead of loading total system supplies
5	Transaction between the embedded generator and its customer is merely a financial transaction – local supplier will still charges for metering and billing cost and QOS and wires if not included in current DUOS.

Table 4: Cost requirements and other advantages for fair access.

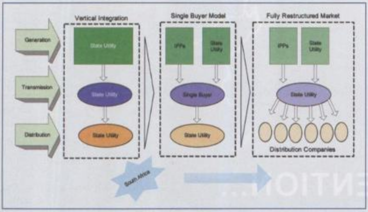

Fig. 10: Possible evolvement of the Electricity Market in SA.

The above serves as an example of the reasons why the single purchaser needs to be independent from the market role players to ensure cost transparency and non discriminatory access. The possibility of unserved energy and the cost thereof is too important a factor for growth not to do so.

Further cost issues where Eskom as the single purchaser may enjoy advantages against IPPs are reflected in Table 4.

Unless ringfenced properly and operated as an independent authority the current arrangement of Eskom as the single purchaser of IPP energy appear to hamper IPP market entrance and thus the availability of adequate supplies in South Africa.

Way forward

New market structure

Much has been said about a possible market structure for SA. In essence it means that the vertically integrated structure would first allow the entrance of a single buyer to source and purchase IPP capacity. Eskom is filling this role currently, but learning from lessons elsewhere, this paper is advocating that the division within Eskom doing this, should be separated from Eskom to be independent and transparent in operation, especially with regard to ring fenced costs. The fragmented distribution system would evolve to six REDs, each including both Eskom distribution companies and municipalities. An independent system operator could take (over time) charge of administering the competitive wholesale market and setting real-time prices for power and ancillary services.

Conclusions

South Africa needs to quickly institute the steps of market restructuring above. By doing so, it will help restore the integrity and reliability of its electrical infrastructure and get itself back on track to record the strong economic growth it has enjoyed in the recent past. Any time a country embarks on electricity market restructuring, it must weigh the costs and benefits of the process. In the case of South Africa, the country has already experienced costs relating to continuing with the status quo, and the costs of market restructuring pale in comparison. One needs to only look at the figures regarding lost output from the commodity sector during the electricity shortages of late 2007 and early 2008 to be convinced that the status quo is unsustainable. Given this the sector needs to muster all support available, especially that of the private sector, but this does not mean that the private sector must dominate and dictate

The benefits of market restructuring are numerous. A restructured market will provide increased incentives for generation development and will make it appear attractive and secure to invest capital in adequate generation capacity to drive economic growth. Multiple large power buyers who have alternative supply sources will enforce operational efficiencies on power generation. South Africa's specific goals of expanding opportunity and Black Economic Empowerment are supported by a policy that allows for the creation of a greater number of independent economic entities. Finally, a less centralized and controlled generation sector will attract additional expertise and innovation into the sector.

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A methodology for the evaluation of cogeneration applications

As a result of the recent shortage of electricity in South Africa and the targets for renewable energy, increasing amounts of embedded generation (EG) are expected to be connected to distribution networks. To accommodate this embedded generation, the existing distribution network should be utilized and developed in an optimal manner.

by M M Bello, C G Carter-Brown, Eskom and R G Coney, Kutlwano Engineering Consulting

Eskom (the national electricity utility) and the National Energy Regulator of South Africa (NERSA) are targeting the connection of cogeneration plant by 2012 (additional programs target other EG including renewable and traditional fossil fuel generation). Initially cogeneration projects with a capacity of at least 1MW will be considered. A cogenerator is a source of electrical power that is a co-product, by product, waste product or residual product of an underlying industrial process. NERSA categorises co-generation as follows [1]:

- Type I: Projects utilising process energy, which would otherwise be under utilised or wasted. (e.g. waste heat recovery).
- Type II: Primary fuel based generation projects, which produce, as part of their core design, other usable energy in addition to electricity (e.g. combined heat and power projects).
- Type III: Renewable fuel-based projects where the renewable fuel source is both the primary source of energy, and is a co-product of an industrial process (e.g. use of bagasse and/or forestry waste from the sugar and paper industries).

Why co-generation?

The strategic reasons for pursuing cogeneration include but are not limited to [2]:

- Potential to deliver capacity quickly.
- Some co-generators may provide electricity at a lower cost than conventional generation.
- Potentially reduces investment in networks and supports distributed generation.
- System losses can be reduced by generating close to load centres.
- Improves industrial energy efficiency and is therefore environmentally friendly.

Technical considerations

Historically, Eskom sub-transmission and distribution networks were designed to transfer power from the high voltage grid to load centres at lower voltages. Urban distribution cable networks are usually looped and operated as radial feeds to reduce fault levels and simplify protection. Rural distribution overhead networks are radial, often with limited interconnectivity.

Impacts of generators on distribution networks

Connecting embedded generators to distribution networks can cause the following network impacts [3, 4, 5, 6]:

- *Equipment thermal ratings:* EG may cause the loading levels of individual elements to increase, specifically in cases of maximum generation and minimum embedded load. Thermal ratings could be exceeded.
- *Rapid voltage change:* Step voltage changes may be caused by inrush currents, which occur when transformers and/or induction generators are energised from the network. A sudden voltage reduction can be experienced when a generator is disconnected.
- *Steady state voltage limits:* During all loading and generation patterns, voltage rise and voltage drop need to be kept within specific limits so that voltage variation at customer points of supply are within required limits as specified in the South African electricity quality of supply regulatory standards [7]. The reverse flow of power from embedded generators may cause voltage rise in networks which have been designed for unidirectional power flow.
- *Fault levels:* Connecting a generator to a distribution network has the effect of increasing the fault levels in the network close to the point of EG connection. This may result in the violation of equipment fault levels ratings.
- *Transient stability:* Generator transient instability is not normally an issue with generators connected to a distribution system [6]. However, generators connected to long lines subject to long protection clearance times could experience transient instability. Multiple generator installations could be particularly prone to instability.
- *Network reliability:* The ability of local EG to improve network performance may be dependent on the ability to island and supply customer loads in the event of network faults that would otherwise result in outages. EG are generally not allowed to island with portions of the utility network and other customers.
- *Technical losses:* Technical losses may increase or decrease due to changes in equipment loading.

Ways of mitigating potential deleterious impacts of generators connected to distribution networks

A number of network options may need to be considered to allow connection of an EG to a distribution network and are described in [3, 4, 5, 6] but are not repeated in this paper.

Eskom EG interconnection standard

According to the South African Distribution Network Code [8], each distributor must have an interconnection standard specifying the technical criteria for the connection of an embedded generator. The Eskom Distribution standard for the interconnection of embedded generators [9], specifies minimum requirements for generator power factor, frequency control, earthing, circuit breaker capacity, protection, synchronisation, metering and telecontrol (indications, remote tripping of the generators and alarms).

EG assessment process

The EG requires a grid connection agreement to be allowed to connect a generator in parallel with the Eskom distribution network. This grid connection agreement is a separate agreement to the commercial agreement which will, for example, address energy tariffs for generation exported into the distribution network. The connected EG might also sell the generated power to Eskom or another party (via wheeling through the Eskom network). The process for the technical assessment of EG connection to the Eskom distribution network [10] is illustrated in Fig. 1.

Project planning

Project planning is a phase initiated by the EG developer who recognises the potential business opportunity of connecting his proposed plant to a distribution network. At this stage, the EG developer would have identified a potential site for the EG, energy resources, types of generating plant and cost estimates for the plant.

Exchange of planning information and preliminary study

At the preliminary stage the EG developer provides the following basic data:

- Number of generating units, type of generator, size (rating) and other electrical parameters.
- Fuel resource.
- Physical location of the plant and single line diagram of the connecting equipment with major internal network equipment parameters.

On receipt of the application, Eskom carries out a preliminary system study (see Fig. 2) which includes:

- Voltage performance: Steady state system voltages must be within standard limits.
- Network adequacy: Equipment and conductor thermal limits must not be exceeded.
- Short-circuit calculations: Equipment fault level ratings must not be exceeded.
- Losses: Relative change in technical losses.
- Load flow study

The planning engineer identifies network options for connection of the EG. The costs of each option that satisfy the technical connection criteria are estimated considering the cost for both dedicated assets (as are required solely for connection of the EG to the network), and shared assets (upstream network reinforcement that supports more than one EG developer or conventional customer). The EG developer pays the full cost of dedicated assets and a Rand per kVA (R/kVA) contribution towards shared network costs.

A summary of the cost is then sent to the EG developer in a form of a feasibility quotation (FQ) to be incorporated in his business case and cost per unit to be sold. Under the pilot national cogeneration project (PNCP), the cogeneration developers were given untill 30 May 2008 to submit their bids.

Normally in Eskom, the FQ is only 65% accurate as a project design has not yet been determined. The EG developer is given four weeks to respond.

Project Design

If the EG developer accepts the FQ, the design phase of the process proceeds. The EG developer pays for the design work. Further system studies are performed as follows:

- Transient stability studies.
- Protection coordination studies.

The connection options, scope and costs are refined and a design quotation (DQ) is issued. The DQ is committed as 100% accurate. On the acceptance of the DQ, the processes for construction, testing and commissioning commence.

Eskom challenges regarding embedded generation connections

The practical challenges associated with the implementation of the proposed process in Eskom Distribution include [11]:

- Distribution planners have not previously been exposed to EG. They require skills and training.
- A shortage of experienced distribution planning staff, which is further compounded by high load growth rates.
- Short timeframes (as required to help address the generation capacity problem) to perform the EG connection evaluations.
- Challenges in practical implementation: This includes delays due to material lead times and environmental impact assessment (EIA). Resources are required to construct and commission the new equipment required for EG connection.
- Data problems: There are deficiencies in existing primary and control plant data such as single line diagrams (SLD), equipment attributes (e.g. alternator impedances) and protection settings.
- Billing systems and tariff structures: Billing systems need to be enhanced to support EG tariffs. Training of customer service staff is required.

Eskom's strategy to support EG grid connection

Given the challenges faced with increased load growth, time constraints, and a skills shortage, Eskom has established the following:

Enabling agreements with consultants

Consultants have been appointed to assist with the technical assessment of co-generation connection applications. The consultants include international experts on EG. An important part of the support is skills transfer to Eskom staff. As part of a broader skills transfer, an engineer (within the Eskom planning technology subdivision) has been seconded to the consultants assisting in the technical assessment of cogeneration connection applications to learn and acquire skills specifically on EG.

Network planning guidelines on the assessment of EG

The Eskom Distribution Network Planning Study Committee have established an embedded generation work group. The primary aim of the work group is to address all network planning technology issues and develop guidelines relating to EG. These guidelines are targeted at the distribution planners so that they can assess, analyse and do system studies for EG applications.

Four guidelines will be developed by the work group within the next 15 months:

- *Network planning guideline for embedded generation (EG) connection to the distribution network – fundamental system studies.*

  This guideline explains the basic theory, the effects of EGs on the networks, core issues for power flow and systems studies, and how EGs can be connected to the distribution networks. It covers fundamental system studies, modeling and connection of embedded generation to the distribution network. The guideline will be published by December 2008. It will be enhanced to accommodate renewable generation technologies such as wind farms.

- *Network planning guideline for embedded generation (EG) connection to the distribution network – examples on steady state studies.*

  In order to support the understanding and application of the fundamental system studies guideline, application examples are required. This document illustrates application examples as formal case studies that demonstrate the theory and application of the EG planning guideline. The guideline will be published by December 2008. Clear directions on the use of models are also provided. This includes actual models already tested in Digsilent PowerFactory.

- *Network planning guideline for embedded generation (EG) connection to the distribution network – advanced system studies.*

  Eskom Distribution network planners have not been exposed to advanced systems studies, stability and insulation coordination analysis of EGs connected to the distribution network. This planning guideline will cover these aspects (including examples of complex system studies), and will be published by December 2009.

- *Data required for embedded generation (EG) connections to the distribution network.*

  In this guideline a master type library will be developed containing generic generator information needed by planners in order to model embedded generators. Models for EG in databases such as SmallWorld will be developed. Data required for future reference (including storage locations) will be established. The guideline will be published by December 2009.

Expected planning guideline outputs

The guidelines will lead planners in the following aspects:

- Basic guidelines whether a project seems feasible, e.g. relative size of generator vs. The fault level.
- How should renewables and embedded generation be evaluated?
  - How should critical and non-critical parameters for the generator be obtained?

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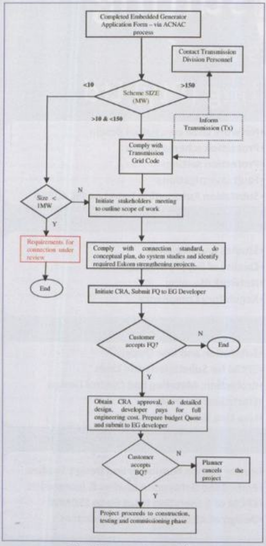

Fig. 1: EG assessment process [10].

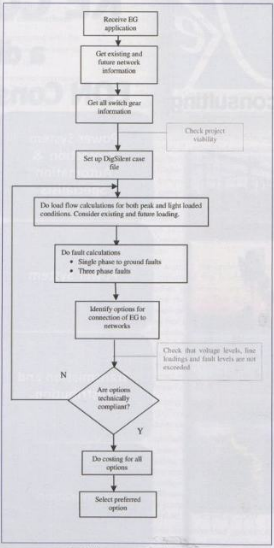

Fig. 2: Planners assessment framework.

- How and where should the above parameters be used in the simulation and for which simulation types?
- Which parameters should be evaluated, e.g. power quality, protection coordination, network stability?
- Which models should be used for which of these parameters? i.e. the basic, intermediate or complex model.
- Which cases should be evaluated?
- Which types of simulation studies should be done, e.g. load-flow, fault studies, stability, harmonic or electromagnetic transient studies?
- What is the expected time requirements for such studies (and which could be neglected if time does not permit)?
- Which indices are required to adequately measure and compare the impact of embedded generation on a network?

- What protection settings should be specified?
- What other operating philosophies should be specified? For example:
  - Under what conditions can EG be reconnected after a trip?
  - Can EG be used for islanded operation – and what control technologies are required for this?
  - Due to the stochastic availability of EG; what are the potential impacts of unavailability?
- What generic study cases should be available for general testing and verification of specific aspects?

Gaps and issues going forward

The following gaps have been identified:

- The widespread integration of numerous small EG sources such as home PV systems presents additional challenges, such as the process and standards for connection, and the management of associated data.
- The present Eskom EG focus is in support of the co-generation applications and future phases expanding beyond co-generation to assist in addressing generation requirements and renewable energy targets. The South African government issued a white paper in 2004 which includes a 15% renewable energy target by 2013 [12].
- Operation and maintenance implications: EG implications on network operating and safety need to be factored into existing policies and procedures.

- Links with international research: Considerable research on EG is being done internationally. Eskom does not intend duplicating international research and needs to assess international research for local relevance. Many of Eskom's sub-transmission and distribution networks are voltage limited and have low fault levels (as compared to developed countries), which may introduce additional constraints and complexities.
- Training of distribution planners: The guidelines produced will also be converted to training modules for distribution planners via the training and standardisation work group under the planning study committee.

Conclusion

The introduction of widespread cogeneration presents technical, planning and human resource challenges to Eskom. The successful completion of the network planning guidelines on the assessment of EG will allow distribution planners to better understand, assess and connect embedded generators to the distribution networks.

Acknowledgement

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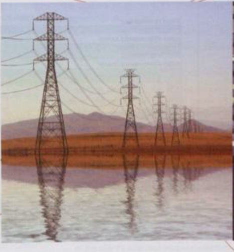

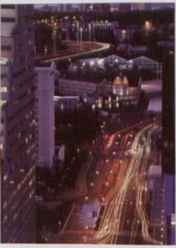

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The virtual power station: a new age in demand side management

The virtual power station (VPS) is a platform that provides the Eskom system operator (SO) with a means to optimally schedule all Eskom's controllable demand side resources. It presents the SO with a consolidated view of all available 'Negawatts' at any given time, along with cost profiles for dispatch, in much the same way as conventional power station scheduling.

by Sizwe Mabanga, Rian Breed and Rob Surtees, Enerweb

The VPS provides a very effective mechanism for achieving peak shifting and in some cases peak removal, thereby improving overall system performance, decreasing the cost of capacity provision and postponing the need to build costly new generation capacity and/or network capacity. It provides the SO with a resource with similar characteristics to a peaking power station or many smaller widely distributed peaking stations.

The approach taken in creating the VPS was to make it indistinguishable from physical power stations from an operational (SO) point of view. Thus when additional load is needed because of an unexpected shortage or an expected peak, the SO can dispatch the VPS as he would perhaps an emergency or supplemental generator. This distributed 'Negawatt' generation is also the cleanest energy source available to the SO and can be deployed faster than any physical energy source of similar capacity.

VPS components

Fig. 1 presents an example of an actual dispatch deployed by the SO through the VPS. This is an excerpt from the aggregated performance report for that event.

There are essentially two types of customers currently incorporated within the VPS viz. those that can reduce load for up to two hours but require prior notification (10 m to day-ahead), termed supplemental reserve customers, and those that can interrupt within 10 s of notification but can only provide the SO with a 10 m (max) load shed interval, termed instantaneous reserve customers. These programmes have been in place for over three years under Eskom's demand market participation (DMP) initiative and have now been incorporated into the VPS to enable efficient and automated dispatch.

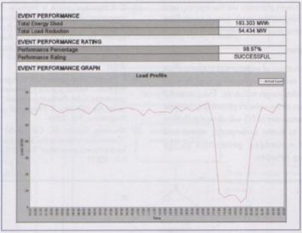

Fig. 1: Example of VPS supplemental reserve event report.

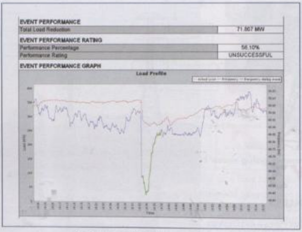

Fig. 2: Example of instantaneous event report.

Fig. 1 illustrates an aggregated supplemental reserve event and Fig. 2, an instantaneous reserve event for an individual customer. While the supplemental customers generally curtail load manually following an interactive voice notification via phone/cell, the instantaneous customers would have an onsite load controller which is enabled directly from the VPS but dispatched automatically through an underfrequency load controller. When the supply frequency drops below a certain point, these customers' controllers automatically shed load and allow the system frequency to recover within the 10 m period. In Fig. 2, while the customer managed to reduce load by 71,8 MW, the contractual reduction was 128 MW and thus termed "unsuccessful". There would therefore be some contractual and financial settlement consequences for the customer in question.

Other loads to be scheduled through the VPS in future include customer standby generators, with pilot studies completed and the product being developed for release by Eskom.

The VPS can effectively include any type of schedulable demand side management (DSM) effort, from ripple control systems through to household level smart metering and advanced metering infrastructure (AMI). Additionally, because of the holistic approach taken in the function development of the VPS, it will perform all contracting, planning, operations, and settlement functions where necessary.

There has been much focus in recent years on the 'smart grid' which achieves distributed control through a network of automated real time load monitors and switches (smart meters), which automatically limit or shed loads under certain network conditions. It is also envisaged that the VPS would interface with these systems, thus enabling central control (SO) to further add to the MWs available for dispatch.

International demand response research

A comprehensive research of comparable international solutions was performed at the onset of the VPS project, with most information being found under the banner of demand response (DR) programmes. It is clear that DR and VPS type solutions are urgently needed by utilities all over the world. California, USA, which is plagued by energy related problems and controversies, has some of the most advanced DR technology and comprehensive literature on the subject.

Most of today's DR solutions have two major challenges:

- System operators need to balance load in real time and cannot tolerate delays in the dispatch process, but the DR systems often have a cumbersome dispatch notification process that goes through multiple channels and multiple hands. The lag time often makes involuntary load shedding the only option available to the SO on short notice. For non-automated systems, where no handsoff system exists that performs the task of curtailing the electricity consumption automatically, participants in a load reduction programme require even more time between notification and the actual load reduction event depending on the process used for powering down.
- Manageability is not built into the systems, thus over-utilisation of participating customers and other contract breaches by beleaguered utilities become problematic.

An effective VPS would need to handle the dispatch notification process, making it fast, direct and error-free, thus enabling realtime load balancing. It would need to have a strong planning component that aggregates individual contract limitations and spreads the available load against a long term forecast. Other qualities expected of a VPS include:

- Wide range of flexibility.
- Trust – security, integrity, and assurance of performance.
- Control – manageability, serviceability, measurement and adaptability.

The benefits of a centralised VPS are:

- Provision of an efficient mechanism to dispatch 'negawatts', thus enabling load shift from a broad customer base.
- A broad view of available load enables system operators to make optimal scheduling decisions.
- Centralised bidding and customer contracting.
- Centralised planning, in emergency and timeahead planning horizons.
- Centralised risk management and decision support;
- Centralised administration enables auditable and cost-effective verification and settlement.
- Centralised operations and support, from participant bidding decision support, all the way through backoffice operations and IT system support.
- The mechanism provides some competitive forces through the bidding process, thus ensuring cost-effective load curtailment is achieved.
- A transparent process gives customers the assurance that they are not cross subsidising others through fair compensation across and within industries/customer groups.
- Improved system reliability.

The VPS's advantages over a large, individual conventional power station included:

- Environmental benefits.
- Faster implementation time.
- The speed with which the VPS can modify its capacity and energy delivery curves.
- Effects of supply from a VPS are distributed, effectively reducing network constraints.

The barriers to successful VPS or DR type programmes were noted as:

- Risks and costs in the establishment.
- Risks and costs in the incentive schemes paying for operations.
- End-user preference for simplicity/luxury.

As research deepened, the various concepts such as AMI, smart metering, and holistic DR began to overlap into the overall idea of a smart grid. The main deliverables of the smart grid are touted as:

- Increasing reliability, efficiency and safety of the power grid (prevent outages, lower CO_2 and lower electricity bills).
- Enabling decentralised power generation so consumers can be both energy client and supplier (provide consumers with an interactive tool to manage energy usage).
- Inclusion of flexibility to power consumption at the client's side and supplier selection (enables distributed generation, solar, wind, biomass, etc.).
- Increase GDP by creating more new, "clean" energy jobs related to renewables, plugin electric vehicles, etc.

The VPS, when deployed in a distributed, decentralised architecture, would enable the above.

A 2007 report, "Power to save: An alternative path to meet electric needs in Texas" prepared for the Natural Resources Defense Council (NRDC), concludes that Texas' growing energy needs can be met at lower cost by using new incentives for businesses and consumers in the state, and by requiring utility companies to invest in cost-effective energy savings before they spend money on expensive new plants. According to the report, together these strategies would yield nearly $50-billion in savings and other economic benefits to Texas over the next 15 years, with an investment of $11-billion – a dividend of more than four to one. Other VPS type products claim they will "make DR 100 times better by reducing costs by a factor of ten while increasing speed and functionality by a similar amount". The VPS will therefore justify the initial costs of development and deployment many times over.

Functional specifications

The establishment of the VPS programme in South Africa was preceded by:

- Selection of technology.
- A technology cost-effectiveness analysis.
- Development of an implementation plan.
- Development of procedures for monitoring and evaluation.

The technologies used were chosen on the basis of ease and speed of development. Thus, Enerweb re-used as much code as possible, accessing an extensive inhouse library geared specifically for such systems, preferring to configure rather than to write new front-ends and back-end processes.

The VPS consists primarily of a central processing station linked to a number of participating sites where manageable load exists. Remote metering (high resolution in some cases) at the supply or billing point of each site is considered a necessity for VPS participation.

The various VPS-participating sites bid in their availability to shed load on a day-ahead basis. Each site is configured on the VPS system with its own set of constraints, which will determine whether a site's bid is accepted or not. The VPS aggregates the selected individual bids and offers it to the Eskom Power Pool (EPP) as a larger amount of available load. The EPP schedules the VPS load to be available the next day in accordance with system load forecasts. The VPS disaggregates the received schedule again into site-specific standby schedules, which are distributed to the sites as a formal notification of standby for the following day.

On the day that the SO requests load reduction from the VPS, the VPS would request the assistance of the participating sites that were scheduled to be on standby. The individual sites would proceed to reduce the requested amount of load at the instructed time. Upon completion of such load reduction events, meter data are collected from each site to measure individual performance and also to calculate settlement amounts due.

The major functionalities of a fully fledged VPS system have been identified as:

- *Contracting:* Responsible for implementation of new products / obtaining DR programmes, as well as management of the customer contracts. Additional functionality such as CRM, document management, help desk and all other customer facing functionalities are housed under the contracting portion of the VPS.
- *Planning (aggregation):* Responsible for producing bids, operation schedules, identification of new products/gaps, medium-term plans and risk management. It is responsible for managing the available contracted capacity based on an 18-month forecast received from the SO. It interfaces daily with the EPP by sending bids that are aggregated using the 18-month forecast, customer parameters and market bids, and receives back an aggregated schedule which it disaggregates for individual customer scheduling.
- *Market operations:* Responsible for the day-to-day operations of the markets, including gathering and verifying bids, participant administration, market parameter management and market closing. Market operations also include a bilateral contract interface, trade reporting and publication of the market results.
- *Operations:* Responsible for load shedding (customer notifications/confirmations, shed signals, etc), measuring customer load behaviour and providing IT services such as hosting and communications, including the management of field devices. Once it receives a disaggregated schedule from planning, operations sends the confirmation to individual customers. National control (NC) dispatches VPS by placing a call to the VPS operator and informing them that they require any number of MWs less than or equal to the amount scheduled on the previous day by EPP. The VPS then notifies customers through a automated telephonic system.
- *Settlements and performance:* Performs the physical and financial settlements. This includes the acquisition of metering data, depending on the VPS operational requirements, performance and financial reporting for individual contracts and EPP. Settlements will also handle all billing and invoicing.

On 1 July 2008 the prototype of VPS went live. The prototype is a DMP focused subset of the full functionality of the VPS. It largely implements planning and operations, but also implements the critical parts of all the other functionalities. Fig. 3 details the implementation scope of the prototype.

Fig. 4 presents a more detailed functional decomposition envisaged for the VPS.

All participants have so far expressed satisfaction with the way the VPS prototype interfaces with legacy systems and the systems

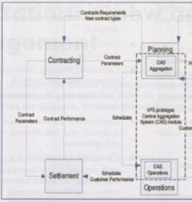

Fig. 3: The scope of the VPS prototype.

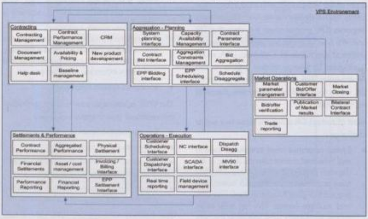

Fig. 4: Functional decomposition of the VPS.

operator finds it much easier to manage and dispatch demand side resources.

Conclusion

Greater real-time control of the load is indispensable to the future of all utilities and saving energy to accommodate increasing demand is far more preferable to building new power stations. Projects such as the VPS world over are making headway towards achieving these ends. Thus the VPS has been designed and built such that integration into the current system is easy, with all the complexities of DR abstracted, yet all the associated advantages still accessible.

Trends in public attitudes towards energy-related matters show a willingness to take greater responsibility in the management of their own power usage. Incentivised DR programmes, standby generation and price responsive consumer behavior are increasingly popular amongst consumers because they understand that the alternative could be generalised load shedding. The VPS provides a solid and generic platform for the implementation and management of these initiatives.

Recommendations

Because the VPS supports a decentralised architecture, each municipality or RED could deploy and manage its own VPS. The potential of a VPS methodology, combined with an enabled AMI, could yield thousands of MWs and avoid the construction of peaking power plant. Municipalities could make their flexible customer load available to the national SOs thus ensuring a much more secure power supply scenario in South Africa.

With the roll out of the AMI, a finer implementation of DSM will be achievable. Implementations of these VPS managed DSM products will reach into the home and allow utilities to monitor, schedule and dispatch, in real time, significant load not currently available.

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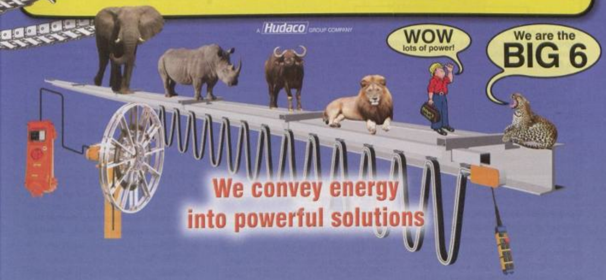

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Investment imperatives to ensure sustainable electrical infrastructure development

Electrical power is vital for any modern day economy. The critical issue today is that demand for electrical power keeps expanding faster than the growth of supply, which is constrained by financial, environmental, technical and manpower related challenges. Despite the many indicators of deteriorating performance, it is evident that access to service is on the increase.

by Deon Vrey and Louis Fourie, NETGroup South Africa

The energy sector is a major player in South Africa's economy and access to electricity significantly affects the country's level of literacy and wealth.

There is a general concern that the electricity distribution business within South Africa is suffering from a lack of investment and recapitalisation of its ageing infrastructure.

Current experience shows that in many instances infrastructure requirements due to growth in demand far exceed the existing conditions, leading to a forced prioritisation of implementation strategies. Implementation plans are normally under pressure mainly due to the lack of sufficient qualified skills and available capital budgets, as well as worldwide pressure on existing resources and material. This situation is further exacerbated by the nature of procurement processes within local government organisations, often leading to extended delivery times. Experience with recent investment planning studies has indicated that it can take between four to five years to practically develop infrastructure required today.

Restoring the integrity of distribution networks throughout South Africa to an acceptable level thus seems to be a mammoth task. A systematic and focused approach should be adopted in identifying and implementing the strengthening and refurbishment requirements that will ensure long-term, sustainable infrastructure. The approach should follow sound and holistic asset management principles.

Current reality

Despite the many indicators of deteriorating performance, it is evident that access to service has increased considerably in terms of both average per capita energy usage as well as percentage of population served. These increases in access have required sustained high rates of investment and expansion, placing an ever increasing burden on entities which do not have sufficient qualified manpower to meet the requirements of both expanding and operating their power systems.

The then NER convened a maintenance summit in 2003, followed by another in 2008, to strategise a response to the concern that electricity distributors are spending far less than required to maintain and refurbish networks to retain the required condition.

One of the critical strategic goals in the creation of REDs is to provide a blueprint for the critical wires processes, governance and key business metrics for the long term desired end-state, based on international best practise. This is intended to strive for excellence in the asset management process, efficiency in CAPEX/OPEX, appropriate to the country's growth and electrification targets, and for the provision of reliable and sustainable service levels. It should therefore be necessary to review and to assess the current short-term infrastructure strengthening and refurbishment strategies and methodologies, and to align those with the identified blueprint for the wires industry.

The current state of the electricity supply industry absolutely points towards the need for an accelerated approach to asset management to ensure that system reliability is adequate for the entire country in the medium to long term. In creating a blueprint for the future electricity supply industry the following best practice gaps needs to be addressed:

Planning and standards processes:

- Network planning processes are inconsistent or executed in a non-standardised manner
- There is a lack of proper maintenance on critical assets and refurbishment planning, as well as execution
- Standards used in the industry differ dramatically
- There is a lack of sufficient skilled capacity and appropriately experienced resources even where the desire exists to attend to issues

The above analysis points to the following as the most important issues to address:

- Holistic and standardised asset management strategies supported by best practice approaches
- Improvement in network and refurbishment planning
- Sufficient resources to support this, inclusive of the availability of technical skills in the long run, and sufficient funding.

Field experience

Experience from field visits as part of refurbishment and network planning exercises has revealed a number of issues that influence the asset management activities, especially with regards to refurbishment and network strengthening.

The following section provides a general view of a number of these important issues that confirms the views of the current state of the industry. These factors must be addressed in implementing the asset management strategies.

Capital program shortfalls

In general the distribution entities have a multi-year rolling plan in place catering for strengthening and refurbishment of the distribution networks. In the majority of cases though, this rolling plan amounts to less than what is required from a sound planning perspective. In most cases the rolling plans are generally based on what the entity can achieve within the existing resource capability and other constraints, often using experience from previous financial years, rather than on what is actually required.

Procurement processes

Without exception, the procurement processes within the distribution entities are not supportive of an efficient electricity business. The process in itself should allow for a structured and auditable mechanism to fairly evaluate and adjudicate procurement activities. The current procurement committees are time consuming and ineffective, resulting in extended lead times for projects to be implemented.

One of the key reasons for the ineffective operation of the procurement process within most of the entities was identified as the lack of the procurement committee's understanding of the technical request at hand.

Skills development and training

Without exception, it was found that distribution entities are under-staffed and that vacancies

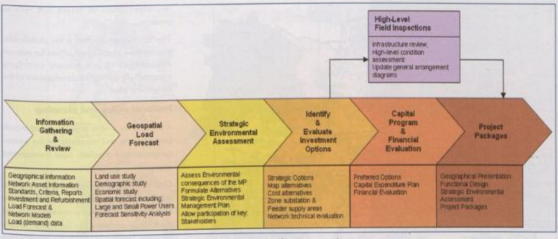

Fig. 1: Investment planning approach.

exist throughout the entire spectrum of the business.

In the majority of the cases, the personnel shortage has resulted in remaining personnel "fighting fires" or required to do work which they are not qualified to do. This shortage has further contributed to deterioration of all major activities including maintenance, planning, construction, as well as safety and security.

Long-term development plans

Not all distribution entities have medium to long-term infrastructure development and refurbishment plans. In the majority however, no significant planning for strengthening and replacement plans are in place. In an alarming number of cases a lack of understanding exists regarding the processes and methods required for distribution network expansion and renewal.

Without these plans, it is impossible to have adequate investment to ensure a sustainable utility, both from a technical and financial point of view.

Infrastructure theft

Theft of electrical infrastructure is currently on the increase, having a detrimental effect on the day-to-day operations of an already understaffed industry. In the majority of cases the direct impact to the economy far outweighs the material cost. A secondary effect of theft is that the focus has turned from pro-active maintenance and operations to reactive replacement of stolen equipment. This needs to be taken into account in the planning, design and operation of the utility.

Network planning principles

Distribution network expansion and renewal planning forms one of the cornerstones of asset management and is the art of spending money today in an efficient manner such that it will have lasting value in the future. Done properly, this is a significant and complicated task that requires detailed distribution system models and computer analysis tools [1]. In general, distribution network planning deals with capacity and reliability analysis [3] as well as network renewal or refurbishment planning. Capacity analysis addresses thermal and voltage limits while reliability, perhaps more importantly, addresses the impact on cost and customer satisfaction.

As discussed in the previous section, apart from Eskom Distribution, only some of the larger metropolitan municipalities and very few of the local municipalities conduct capacity analysis in a structured and auditable manner. Refurbishment planning forms part of the long-term strategy but is rarely done on a consistent basis. Reliability analysis is currently in its infancy and is only done in some of the Eskom Distribution regions. The following sections provide a high-level overview of a typical best-practice distribution network planning process, as well as basic aspects of some of the most important building blocks of capacity analysis and network refurbishment planning. Following these principles and processes in a structured manner, will have a major impact on the adequacy of the electricity distribution industry in the medium to long-term.

Fundamental network planning process

A typical long-term distribution network investment plan follows the generic process as outlined in Fig. 1.

The process involves aspects such as general and specific information gathering and reviews, strategic studies to support a spatial or geographically-based load forecast, field inspections to support practical project definition and refurbishment plans, strategic environmental assessments, network assessments and scenario planning as well as cost estimates, financial analysis and project definitions.

The following sections provide insight to some of the most important building blocks of this general process.

Long-term load forecast

Regarded as one of the most important inputs to long-term strategic planning, the aim of load forecasting is to determine the present and future electricity requirements of electrical end-users within a specific spatial area in order to reconcile this with the available resources and electrical services [2]. The forecast normally presents a dynamic assessment in terms of historic and the most probable future trends.

The focus throughout the forecast falls on the electricity needs and requirements of the various user sectors as determined by the characteristics and trends of each. The forecast therefore highlights where and when imbalances between electricity requirements and supply are most likely to occur. This informs decisions required for the timeous development of electricity infrastructure options, the spatial location and level of intensity per user group. A proper load forecast thus provides the network planner with a spatial view (location, timing, growth patterns, density and electrical characteristics) of the long-term electricity need scenarios, which form the basis for the electrical infrastructure requirements.

Equipment condition assessment

Aging equipment is undoubtedly one of the primary concerns for asset owners. Failure rates increase as equipment ages and requires proportionally more inspection and additional maintenance cost than new equipment [4].

A life extension or refurbishment program that permits continued economical operation of the electrical system and improved reliability by reducing failures must address both:

- Individual substation facilities as they approach design life, and
- Individual equipment on a system wide basis.

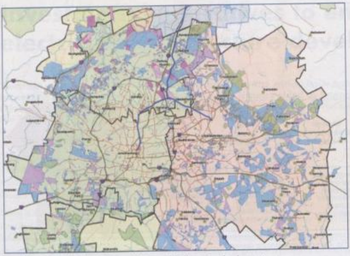

Fig. 2: Potential short- and medium-term developments.

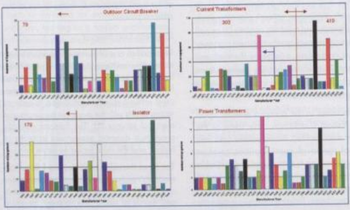

Fig. 3: Equipment age profiles.

Asset specific assessment normally provides a systematic estimate of the remaining life in substation and line facilities. In conjunction with the life extension methodologies, it can further provide a planned programme to extend that life to meet future needs [5]. The output from an equipment condition assessment study should clearly indicate:

- Assets posing an immediate safety hazard or those that require immediate to short-term replacement based on assessment outcomes or policy (critical assets)
- Assets that require monitoring or testing to assess actual conditions (concerning assets)
- Assets that operate satisfactory under intended conditions (normal assets)

It is important that asset replacement and renewal strategies should be executed in conjunction with strengthening and expansion strategies.

Environmental impact

Being pro-active in assessing the potential impact of infrastructure on the environment during the planning phase can have a significant effect on construction lead times. Such a pro-active approach involves a strategic environmental assessment (SEA) which includes the use of a multi-disciplinary team of environmental experts and specialists to assess the potential environmental consequences of a strategic long-term infrastructure investment plan on the environment. Alternative plans and strategies can be formulated where required.

The SEA normally focuses on understanding the biophysical, social and economic environment and the values of these. Opportunities, constraints and values of the study area, including the needs and desires of the relevant stakeholders are assessed. These are then formulated into a desired state of the environment that recognises appropriate development options. The long-term development plan is then evaluated against a set of sustainability criteria. A strategic environmental management plan is then normally used to guide the implementation of future EIA related projects.

The SEA further involves a key stakeholder engagement phase which allows for relevant stakeholders to pro-actively contribute meaningfully during the development of the investment plan.

National policy and planning

A blueprint for a wires business should include best practices and standards for the various components of a holistic asset management approach.

One of the items is planning and standards, with particular focus on network planning. It is therefore imperative that a national policy and guideline be established for distribution network planning. This should include the strengthening of available analytical tools and practical methodologies.

The national policy is underpinned by the availability of appropriate technical skills. It is therefore essential that a capacity building, training and skills development program be established and coordinated to ensure sufficient skills available for refurbishment and network planning in support of the asset management strategy.

Utility funding

A utility can only function effectively if sufficient funds are available for operational purposes, as well as for capital related projects, as identified through the network planning and refurbishment exercise and coordinated within a network master plan framework.

The funding of utility operations should be based on a prudent cost recovery principle; therefore utility tariffs should provide sufficient revenues to satisfy these needs. Two types of expenses need to be considered; namely operational expenses to cover the day-to-day operation of the utility, and secondly capital related expenses to establish, and retain in good order, an electrical network that can supply the customers electrical needs.

As revenues generated from sales are not in all cases on a true cost recovery basis, NERSA has provided guidelines for expenses in determining tariffs, i.e. 5% of revenues for network maintenance, refurbishment and recapitalisation, and 17% towards capital expenditure.

Operational expenses should always be executed on a cash basis, funded from revenues from electricity sales at agreed tariff levels.

Capital expenditure can be funded in a variety of ways, i.e. government grants for specific projects, loans serviced by cash generated from sales and directly from revenues generated by sales.

Fig. 4: Geology, ecology, hydrology, historical sites, visual impacts etc.

A utility should determine the funding mix in such a way that the return on assets is maximised, to maintain a healthy debt/ equity ratio, and to minimise the impact on tariffs, while maintaining a sufficient asset base to supply the required electrical energy. A funding plan and strategy should therefore consist of the right mix of the funding options available.

By not providing sufficient funding for normal operations, the performance of equipment will deteriorate, as maintenance will be neglected. A shortage of funding for capital related projects will result in these projects being delayed, preventing the customer base, and sales volumes from growing, which will negatively affect the national economy. This has been experienced lately with the shortage of generation capacity and other performance related power outages. It has been proven through financial modelling that growth of the utility in terms of sales and customer base is required for a utility to remain sustainable.

Prudent tariffs should be based on cost recovery for electricity services only. In the past revenues from electricity sales were used to subsidise other services within municipalities, and then disproportionately allocated, resulting in revenues generated from electricity sales not being made available for electricity related activities, like network maintenance or refurbishment. This could be corrected in future by providing government grants for municipal services, i.e. to avoid the historical cross-subsidies.

It should be a goal for the electricity distribution industry that electricity sales only recover relevant costs, thereby eliminating cross-subsidies for other services.

Where current resources and funding is insufficient, a backlog will be created in maintenance, refurbishment and short-term strengthening. This will need leadership in future funding strategies to prevent or overcome this problem.

Conclusion

It is clear that the long-term sustainability of a utility depends on proper network planning to support the growth in new customers and sales. This must incorporate refurbishment planning, as the replacement of outdated equipment should be taken into account in the long-term network alternatives.

Appropriate funds should be allocated for the day-to-day operation of the utility, supported by sufficient technically skilled staff.

The current situation in South Africa requires leadership to bridge the technical skills gap, and to assist in establishing proper asset management strategies.

The success of tomorrow is based on best planning today.

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Maintenance management plan: the Tshwane experience

The maintenance philosophy standards and procedures of the entire secondary network in the nine depots forming the City of Tshwane jurisdiction and licensed areas are similar. Emphasis is placed on ensuring a safe network while the majority of the maintenance activities can be ascribed to breakdown maintenance.

by P M Tlabela, City of Tshwane

The balance of the repairs and maintenance budget is utilised for the preventative maintenance. It was agreed at a Council Lekgotla that the repairs and maintenance budget allocations be expressed as a percentage of the replacement value of the different categories of the assets sometimes in 2005. It is generally accepted that the repairs and maintenance budget should be in the region of 5% of the asset replacement value. The Engineers in the CoT are being entrusted with the rollout of the maintenance plan while adhering to the applicable Acts and utilising all processes and support in the execution of this nerve centre of the electricity department.

Background

The City of Tshwane Metropolitan Municipality was formed in 2000 by the amalgamation of 13 councils incorporating under the Municipal Structures Act (Act 117 of 1998), Greater Pretoria Metropolitan Council, City Council of Pretoria, Town Council of Centurion, Northern Pretoria Metropolitan Substructure, Hammanskraal Local Area Committee, Transitional Representative Councils of Mabopane, GaRankua, Winterveldt, Temba, Pienaarsrivier and Crocodile River, Portions of the Eastern and Western Gauteng Services Councils, and portions of the Eastern District Council (see Fig .1).

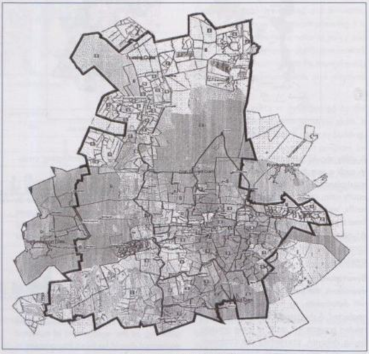


Fig. 1: Map of City of Tswane.

The electricity department of the CoT is one of the service delivery departments under the Public Works and Infrastructure Development cluster with both the MMC (as political head) and SEO as administration head. It consists of two general managers and one is solely responsible for distribution operations.

The distribution operation division comprises of both the distribution regions (with depots) and technical services section responsible for operation of the entire network. This can be illustrated as in Fig. 2, and all the deliberation will be confined to this division and to some extent may touch on supporting structures where necessary. As can be noted, the division has the majority of the human capital to execute the nerve centre of the organisation.

Distribution depots

The City of Tshwane is divided into nine geographical depot service areas.

Distribution Operation North

The distribution operation north depots comprise of the following six depots:

- Atteridgevilie/Fortsig depot
- Princess Park depot
- Rosslyn depot
- Soshanguve depot/Babelegi depot
- Wonderboom
- Eskom areas

Distribution Operation South Depots

The Distribution Operation South Depots comprise of the following four depots:

- Centurion depot
- Pretorius Park depot
- Waltloo depot
- Princess Park

Depot functions

The function of the distribution depots is primarily to attend to the following aspects on the electrical network:

- Safety
- Breakdowns due to faults or theft
- Repairs and maintenance
- Depot management (e.g. resources management etc.)

Types of maintenance

Studies have shown that there are three types of maintenance i.e. corrective, preventative and refurbishment maintenance. One can add in detective maintenance - this applies to the type of devices that only need to work when required and do not tell us when they are in the failed state e.g. fire alarm or smoke detector. They generally require a periodic functional check to ascertain that they are still working. The preventative maintenance can furthermore be divided into two which is either time based or condition based. All these are being considered when one generates a tactical maintenance planning based on short

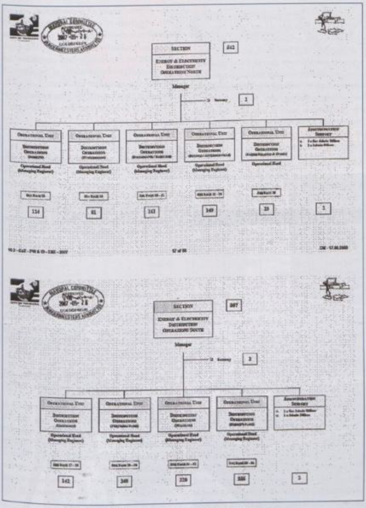


Fig. 2 and 3: Distribution operation organisation top structure.

or long term strategy. Among the main strategic decisions that used to be taken in maintenance is the level of maintenance that is required to achieve the maintenance objectives within the budget constraints of any organisation.

Models in maintenance

The need for models

Modelling is the most common method used for analysing a system and supporting the decision-making capability during both the design and operational phase of the system life cycle. Modelling is the cheapest and fastest way of studying the effects of changes in key design variables on system performance. The purpose of modelling is to understand, predict, control and ultimately improve system behaviour. Maintenance models are used to enable the maintenance manager to make better decisions. Typical decisions for the maintenance manager or supervisor are as follows:

- What maintenance type or strategy should be used for an equipment or item?
- How frequently should preventative maintenance be performed?
- When should an asset be discarded or replaced?
- What spares and how many of each type should be kept in the store?

This decision making process is simplified by using models, especially analytical or mathematical models. The complexity of the maintenance environment has led to the development of a variety of mathematical models for different aspects of the maintenance function. Some basic principles of availability, reliability and maintainability are discussed in the next sections.

Reliability

The reliability of an item can be defined as the probability that the item will function without failure for a specified time under specified conditions. Most reliability phenomena are understood in terms of the number of failures in a time interval or time until failure. Reliability is expressed mathematically by means of five related functions. These functions and symbols commonly used are indicated in Table 1.

Function	Symbol	Unit
Failure density	$f(t)$	-
Reliability	$R(t)$	-
Cumulative distribution function for failure (CDF)	$f(t)$	-
Failure of hazard rate	$\lambda(t)$	time $^{-1}$
Mean time to failure	*MTTF*	time

Table 1. Functions and symbols of reliability.

Knowledge of the failure probability distribution, e.g. function $f(t)$ or $\lambda(t)$, can be used to determine any of the other functions in Table 1. Formulas for each function are given by Lewis [2], but these functions can also be calculated for specific distributions by means of spreadsheets that have built-in probability distributions.

Most reliability phenomena can be described by means of the exponential distribution that results from random failure behaviour of electrical equipment. If the failure rate of an item is constant, therefore independent of its age of operating history, the reliability is expressed by the exponential distribution. The failure rate $\lambda(t)$ is a constant, λ and the reliability functions are then given by:

$$f(t) = \lambda.exp(-\lambda t)$$
$$R(t) = exp(-\lambda t)$$
$$MTTF = \frac{1}{\lambda}$$

However, not all phenomena can be described by the constant failure rate model. Some complex assemblies e.g. C/B/batteries/relays or items exhibit early failures, while failures due to wear-out also occur. This leads to the well known bathtub failure rate model.

Probability distributions with a time dependent failure rate are needed to model the wear-in failures (a decreasing failure rate) and the wear out failures (an increasing failure rate). The normal distribution can be used to model a decreasing failure rate. However, the well known Weibull distribution is generally preferred to model an increasing, constant or decreasing failure rate. The reliability functions for the two-parameter Weibull distribution are:

$$\lambda(t) = \frac{m}{\theta}\left(\frac{t}{\theta}\right)^{m-1}$$
$$f(t) = \frac{m}{\theta}\left(\frac{t}{\theta}\right)^{m-1}.exp\left[-\left(\frac{t}{\theta}\right)^{m}\right]$$
$$R(t) = exp\left[-\left(\frac{t}{\theta}\right)^{m}\right]$$
$$f(t) = \frac{m}{\theta}\left(\frac{t}{\theta}\right)^{m-1}.exp\left[-\left(\frac{t}{\theta}\right)^{m}\right]$$

In these equations the two parameters m and θ must both be positive. The parameter m is known as the shape parameter and θ is known as the characteristic life. The mean time to failure equation, MTTF for the Weibull distribution cannot be calculated by means of a symbol equation, but the techniques are described in the literature [2]. The value of the parameter m determines the nature of the reliability functions of the Weibull distribution. If $m < 1$ a decreasing failure rate is modelled, for $m = 1$ the constant failure rate is modelled, and for $m > 1$, an increasing failure rate is modelled.

- Example of Reliability calculation for the Weibull distribution

The failure characteristics of a switch in an electrical distribution board have a Weibull distribution. The value of the shape parameter, m, is 3,5 and the characteristics life, θ is 60 days. Calculate the reliability of the switch after 40 days and after 80 days.

Solution:

- **Reliability after 40 days:** $R(40) = \exp\left[-\left(\frac{40}{60}\right)^{3.5}\right] = 0.785$
- **Reliability after 80 days:** $R(80) = \exp\left[-\left(\frac{80}{60}\right)^{3.5}\right] = 0.065$

Graphical illustrations of the failure density, reliability and failure rate functions for the exponential, normal and Weibull distributions are given by Pintelon et al [3]. Knowledge of the failure characteristics of an item is of utmost importance in selecting an appropriate maintenance policy or action. Some data is available for certain classes of components (electrical, electronic, mechanical, etc.), but data should also be collected for a specific component or item to build some failure history.

Curve fitting techniques to determine the parameters of the Weibull (m and θ), normal or exponential distributions from failure data are described by Smith [4] and Lewis [2].

System reliability

The components of a complex system are functionally related to each other through a series relationship, a parallel relationship or a combination of these.

The following equations can be used to calculate the reliability of the total system, $R_s(t)$ for each of the configurations i.e. series, parallel and/or a combination:

- $R_s(t) = R_A(t).R_B(t).R_C(t)$
- $R_s(t) = 1 - [1 - R_A(t)][1 - R_B(t)][1 - R_C(t)]$
- $R_s(t) = R_A.\{1 - (1 - R_B.R_D).(1 - R_C.R_E)\}.R_F$

In evaluating combined series parallel configurations, the reliability of sub-assemblies is evaluated first, and the total system reliability is then evaluated by combining the sub-assemblies. A reliability block diagram (RBD) indicating a breakdown from system to components is usually constructed before system reliability can be determined.

Maintainability

The maintainability of an item can be defined as the probability that an item can be returned to a specified functional level within a specific time period. Maintainability therefore addresses issues such as diagnostics, standardisation, accessibility, interchangibility, mounting, labelling, etc. A system should be designed in such a way that it can be maintained easily without large investments in time, money and resources (personnel, materials, tools and facilities).

Maintainability can also be expressed mathematically by means of five interrelated functions, similar to those defined in reliability. These functions are given Table 2:

Function	Symbol	Unit
Repair density	$m(t)$	-
Maintainability	$M(t)$	-
Cumulative distribution function (CDF) for repair	$G(t)$	-
Repair rate	$v(t)$	$time^{-1}$
Mean time to repair	$MTTR$	$time$

Table 2: Functions and symbols of maintenability.

The same distributions that are used for reliability can also be used for modelling repair times. If a constant rate, $v(t) = v$, is assumed, the exponential distribution applies and the following equations can be used:

$$m(t) = v.\exp(-vt)$$
$$M(t) = 1 - \exp(-vt)$$
$$MTTR = \frac{1}{v}$$

The repair distribution (exponential, Weibull, etc.), as well as the values of the parameters of the distribution, can be obtained for simple maintenance tasks by measuring the time taken to perform the task several times and applying a curve fitting technique to the CDF curve. Maintainability is mostly expressed in terms of the mean time to repair (MTTR).

Example of maintainability calculations: The repair rate for the replacement of the main 800A LF, C/B in a 315 kVA m/s is constant at 0,05 min^{-1}. Determine the maintainability of the bearing and the MTTR.

Solution

Constant repair $v = 0.05\, min^{-1}$
Maintainability $M = \exp(-vt) = \exp(-0.05.90) = 0.011 \rightarrow$
Mean time to repair $MTTR = \frac{1}{v} = \frac{1}{0.05} = 20\, min \rightarrow$

Availability

The availability of an item can be defined as the probability that an item will, when used under specified conditions, operate satisfactorily and effectively. Various measures of availability are used in industry, but the most general measure is the operational availability, A_o which is given by the equation:

$$A_o = \frac{uptime}{uptime + downtime}$$

The physical assets of a distribution network are acquired to provide availability and therefore a certain capacity of production or service. Availability is an extremely important attribute of any system and comprises the reliability and maintainability of the system. If an item has a constant failure rate, $\lambda(t) = \lambda$ as well as a constant $v(t) = v$, the availability of the item is given by the following equation:

$$A_o = \frac{v}{v + \lambda}$$

Since reliability and maintainability are mostly fixed by the design of the technical system, the availability is also fixed. The design and systems engineer of a new system has a great responsibility to design for reliability and maintainability to ensure that the availability of the system is adequate.

SAIDI (system average interruption duration index)

The SAIDI of a network indicates the duration of a sustained interruption the average customer would experience per annum. This excludes re-interruptions. It is commonly measured in customer minutes or customer hours of interruption. Mathematically SAIDI can be expressed as:

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

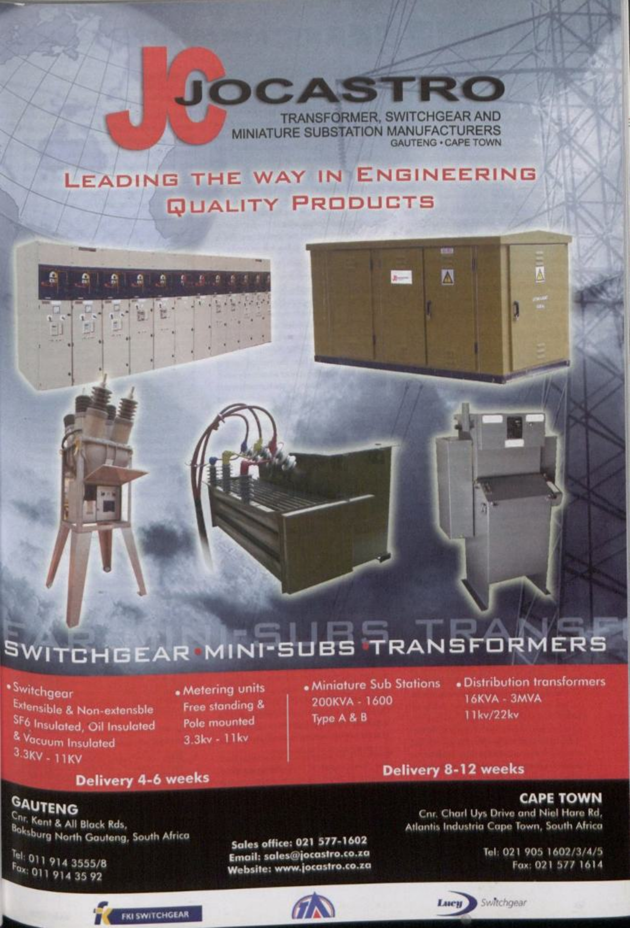
SAIDI calculation: From a duration point of view, 900 customers experienced two 10 minute interruptions and 300 customers experienced a 3 hour interruption. SAIDI for the network effectively calculates the average duration that the 1200 customers on the network experienced. The measurement units are in hours, so 10 minutes equals 0,167 hours in the calculation below:

$$SAIDI = \frac{(900 \times 0.167) + (300 \times 3) + (900 \times 0.167)}{1200} = 1$$

On average the 1200 customers were affected for one hour. The bulk of the customers (900) experienced 20 minutes total duration during the planned outage and the smaller group of customers, experienced the long outage duration of three hours. This explains why the average duration tends towards 20 minutes.

With the pre-arranged event criteria considered, the interruptions would be considered as a single interruption lasting three hours for the customers affected by the pre-arranged planned interruption (which are 1200 customers of the example above). The interruption time is taken from the first operation carried out under the same cause code till the last operation carried out under that cause code. SAIDI for the network would be calculated as follows:

$$SAIDI = \frac{(1200 \times 3)}{1200} = 3$$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MINIATURE SUBSTATION MANUFACTURERS
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LEADING THE WAY IN ENGINEERING
QUALITY PRODUCTS
SWITCHGEAR • MINI-SUBS • TRANSFORMERS
• Switchgear
Extensible & Non-extensble
SF6 Insulated, Oil Insulated
& Vacuum Insulated
3.3KV - 11KV
• Metering units
Free standing &
Pole mounted
3.3kv - 11kv
Delivery 4-6 weeks
• Miniature Sub Stations
200KVA - 1600
Type A & B
• Distribution transformers
16KVA - 3MVA
11kv/22kv
Delivery 8-12 weeks
GAUTENG
Cnr. Kent & All Black Rds,
Boksburg North Gauteng, South Africa
Tel: 011 914 3555/8
Fax: 011 914 35 92
Sales office: 021 577-1602
Email: sales@jocastro.co.za
Website: www.jocastro.co.za
CAPE TOWN
Cnr. Charl Uys Drive and Niel Hare Rd,
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Tel: 021 905 1602/3/4/5
Fax: 021 577 1614
FKI SWITCHGEAR
Lucy Switchgear

From the above example, it can be seen that the isolation of the 300 customers before work started did not benefit the SAIDI figure. The least amount of customers needs to be affected from the start of the interruption up to the end of the pre-arranged event. If there has been a current breaking device on a section, only 300 customers would have been affected. The SAIDI of the network would then have been:

$$ASAI = \frac{(300 \times 3)}{1200} = 0.75$$

ASAI (average service availability index): The ASAI represents the fraction of time (often expressed as a percentage) that a customer has received supply during one year. ASAI is a useful index for measuring the availability of supply of customers with firm supplies. Mathematically ASAI can be expressed as:

$$ASAI = \frac{\text{Customer hours service availability p.a.}}{\text{customer hours service demand p.a.}}$$

Note: There are 8760 hours in a non-leap year and 8764 hours in a leap year.

Alternatively ASAI can be expressed as:

$$ASAI = 1 \frac{SAIDI}{8760}$$

Maintenance strategies

Apart from detective maintenance, the central problem that companies have struggled with is how to make the choice between the other three. This has led to increasing interest within the industry in two strategies, which offer a path to long term continuous improvement rather than the promise of a quick fix. These are reliability centred maintenance (RCM) and total protective maintenance (TPM).

Reliability centred maintenance (RCM)

This strategic change is known as reliability centred maintenance and incorporates within its several distinct shifts in the way we view physical assets and their up keep.

The development of RCM has allowed us to literally re-define maintenance. It re-focuses our thinking by differing in four very significant ways from all that went before it:

The objective of a successful PM program is to prevent or mitigate the consequences of failures, not to prevent the failures themselves. Of the thousands of possible failure modes on any facility installation, each has a different effect on e.g. safety operations, environment or cost. It is the failure consequence that determines what, if any resources will be used to prevent their occurrence. This leads to the conclusion that if the consequence of a failure does not have an adverse effect on safety, operations, environment or cost, then there is no need to carry out scheduled maintenance.

The consequences of failure differ depending on where and how items are installed and operated. For example, missing an appointment is a likely outcome of mechanical breakdown of a car usually driven in urban areas, however the same failure in the middle of the Sahara desert will have much more severe consequences. A formal review of failure consequences focuses attention on maintenance tasks that have most effect, and diverts energy away from those which have little or no effect. This helps ensure that whatever is spent on maintenance is spent where it will do the most good.

We no longer assume that all failures can be prevented by PM or that even if they could be prevented, that it would be desirable to do so. Consider punctures of car tyres, what affects the number of failure rate is the number of nails on the road, not the age of tyre. PM is simply not applicable to this failure mode.

We are concerned principally with what we want the equipment to do, not what it actually is. Say we need a handheld, portable writing instrument, capable of producing erasable text and lines in the width range 0,2 to 0,5 mm. Both wooden and mechanical (propelling) pencils broadly satisfy this simple description. The specification of what we need is independent from the method used to achieve it. By identifying what we actually want, we focus our maintenance on what matters and identify any gaps in the required performance and that is what the system is capable of.

RCM builds on these simple ideas to determine applicable and effective maintenance for each failure. The mechanics of the RCM process itself are well described by other authors.

The power of RCM is not in doubt. There is more than enough hard evidence from manufacturing, extractive, transport and process industries that prove the techniques value in establishing and improving system maintenance. It is however a sharp tool, and is usually best applied in selected areas rather than broadly across a facility. To achieve worthwhile results it must also be carried out by (or at least with) the actual operators and maintainers of the systems in question. RCM is not a "quick fix" solution; time and effort must be invested on training, raising awareness, execution and implementation.

It does however achieve an understanding of how plant works, what it can (or cannot) achieve, and the causes of failure. By doing so it focuses maintenance effort on those areas where it is beneficial. The analysis itself is carried out in groups consisting of experienced supervisors, and specialists (if needed). These groups set up maintenance tasks and an ownership concept is developed.

The development of RCM led to a radical change of direction in our understanding of maintenance and its performance and has presented us with what were entirely new concepts. Today, maintenance directly influences the core aspects of modern business, safety and environmental integrity, energy efficiency, quality, uptime and costs. RCM forms the core of any effective maintenance policy and should therefore be at the heart of your business.

Total productive maintenance (TPM)

TPM is a manufacturing-led initiative that emphasises the importance of people, a "can do" and "continuous improvement" philosophy and the importance of production and maintenance staff working together. It is presented as a key part of an overall manufacturing philosophy. In essence, TPM seeks to reshape the organisation to liberate its own potential.

The modern business world is a rapidly changing environment, so the last thing a company needs if it is to compete in the global marketplace is to get in its own way because of the way in which it approaches the business of looking after its income generating physical assets. So, TPM is concerned with the fundamental rethink of business processes to achieve improvements in cost, quality, speed etc. It encourages radical changes, such as;

- Flatter organisational structures – fewer managers, empowered teams.
- Multi-skilled workforce.
- Rigorous reappraisal of the way things are done – often with the goal of simplification.

  It also places these changes within a culture of betterment underpinned by continuous improvement monitored through the use of appropriate measurement. The principal measure is known as the overall equipment effectiveness (OEE). This figure ties the "six big losses":

- Equipment downtime
- Engineering adjustment
- Minor stoppages
- Unplanned breaks.
- Time spent making reject product
- Waste

To three measurables:

- Availability (time), performance (speed) and yield (quality).
- When the losses from time x speed x quality are multiplied together, the resulting OEE figure shows the performance of any equipment or product line.
- TPM sites are encouraged to both set goals for OEE and measure deviations from these. Problem-solving groups then seek to eliminate difficulties and enhance performance.

Many TPM sites have made excellent progress in a number of areas. These include:

- Better understanding of the performance of their equipment (what they are achieving in OEE terms and what the reasons are for non-achievement).
- Better understanding of equipment criticality and where it is worth deploying improvement effort and potential benefits.
- Improved teamwork and a less adversarial approach between production and maintenance.
- Improved procedures for changeovers and set-ups, carrying out frequent

maintenance tasks, better training of operators and maintainers, which all lead to reduced costs and better service,

- General increased enthusiasm from involvement of the workforce.

However the central paradox of the whole TPM Process is that, given that TPM is supposed to be about doing better maintenance, why do proponents end up with (largely) the same discredited schedules that they had already (albeit now being done by different people)? This is the central paradox, yes, the organisation is more empowered, and reshaped to allow us to carry out maintenance in the modern arena, but we are still left with the problem of what maintenance should be done.

Reliability and maintenance optimisation software

Maintenance 2000 has developed proprietary software packages to conduct reliability centred maintenance analyses, perform RAM (reliability, availability and maintainability),simulation modelling, provide reliability data, reliability calculations and optimise maintenance strategies:

- *RCM Professional:* RCM Pro is an easy-to-use yet powerful reliability software program designed to hold, manipulate, and analyse reliability-centred maintenance data in an intuitive, structured and flexible way. RCM Pro will hold any number of projects, with only one being open for input at anyone time. A project may be of any size, from a single function with an associated functional failure and failure mode, to (for example) the safety systems on an oil platform.
- *PLASMA:* PLASMA (plant simulation analysis) is a powerful RAM (reliability, availability and maintainability) simulator which will enable you to analyse the availability and reliability of complex and dependent systems efficiently and accurately. Conventional analytical tools such steady state availability calculations are unable to fully account for all relevant variables and are usually based on a "snap shot in time". They can tell you what is possible, not what is probable.
- *FARADIP:* FARADIP (failure rate data in perspective) is one of the largest failure rate and failure mode data banks in the reliability profession. FARADIP has been available for 10 years and is now widely used as a data reference. It provides failure rate data ranges for a nested hierarchy of items covering electrical, electronic, mechanical, pneumatic, instrumentation and protective devices. Failure mode percentages are also provided.
- *COMPARE:* A quantified reliability centred maintenance package with graphical outputs for use in word processing. It allows:
- Weibull analysis of failure times with graphical plots and three independent means of assessing significance.
- Optimum replacement intervals for given costs.
- Optimum proof-test intervals for given costs.
- System availability and optimum spares holding calculations (using a MARKOV model).
- *TTREE:* A low cost fault TTREE package which nevertheless offers the majority of functions and array sizes normally required in reliability analysis. TTREE is highly user friendly and, unlike more complicated products, can be assimilated in less than an hour. It has graphical outputs for use in word processing packages.
- *BETAPLUS:* D Smith [4] has developed and calibrated a new generation common cause failure partial beta model.

Maintenance philosophy, standards and procedures of City of Tshwane

For the distribution network i.e. 11 kV to 220 V the following categories are applied as far as maintenance is concerned:

Substations

Preventative maintenance is applied to the substation batteries. The depots have defined two levels of battery maintenance, namely, a major service and a minor battery service.

Overheads

While various activities are scheduled for maintenance in accordance with the maintenance plan, the majority of the maintenance activities performed on the power line networks are prompted by breakdowns and comprises of the repairs to MV and LV networks following a power failure.

The scheduled maintenance activities includes the maintenance of the overhead MV and LV networks, the cleaning and painting of poles and the cutting of trees. These items take place in accordance with a predetermined sequence. The remaining items in this category are related to training, idle time, supervision over contractors and upgrading of overhead power lines.

Cables

As in the case with the power lines, the majority of the maintenance performed on the cable network is prompted by breakdowns and damage to the underground cable network.

Technological tools used in planning and scheduling

SAP PM

The good of this system is that the works engineers input all their requirements for preventative maintenance into the program and when the time arrives to service/maintain electrical equipment, a works order is generated by the system to ensure that the work is done and cleared. The system has other capabilities as well, viz. financial, etc. Other modules that are very effective in SAP PM are SAP PM (02) which deals with proactive maintenance part of the network.

Power map

As required by law, all activities done on an engineering or electrical network should be recorded. The CoT has a log sheet management system, where all steps being performed manually or through a SCADA system are being recorded and archived. The capability of the system is that it also manages resources like fleet management, overtime, standby allocation, NRS data etc.

- *Log sheets*

  Flowing out of control room are two sets of log sheets, one for single complaints e.g. C/b reset and the other for system faults. In any event where the work cannot be processed and restored to original schematic due to a persistent fault like a damaged 11 kV cable, the job is over flown to what is termed abnormal situation. Out of the control room a calculation is made to get the ASAI to ensure that at any given time the availability is over 98%, however during load shedding exercises this year the figure could have changed. The division is still compiling the impact report of load shedding in CoT.

- *Abnormals*

  Abnormal management is a very tardy process: All abnormals must be repaired within 24 hours of occurrence. The system configuration must be normalised as soon as the repair work is completed.

Budgeting and resource allocation

Zero-based budgeting, maintenance scheduling, planning and depot assets

Table 3 reflects the model used by the depots to allocate resources like funds, artisans, vehicles to specific tasks over a period. The contents given in Table 3 indicate the time taken to fix a particular problem of routine maintenance on electrical equipment.

Maintenance management plan

Every year the distribution section reviews its management maintenance plan to be in line with the budgeted requirements and compatible with all the programs such as SAP PM, etc. However, some distortion is been encountered due to escalation in theft of copper conductors which runs in the region of R22-million.

Lessons learned

Just like humans, electrical equipment ages overtime, and this can be accelerated if the system is overloaded and not being maintained properly especially due to

Item	Task Description	Measure		Constant	Depot A Total amount of equipment	Depot B Total amount of equipment
		Substations maintenance				
1	Oil breaker maintenance	Per oil breaker	7% of oil circuit breakers	0,070	1 292,00	1 110,00
2	Gas breaker maintenance					-
3	Cleaning substation yards	Per substation	Twice yearly	2,000	24,00	148,00
4	Electrical maintenance of substation buildings	Per substation	Yearly for 50% of substation	0,500	24,00	148,00
5	Battery inspection	Per substation	Monthly	12,000	248,00	21,00
6	Replace batteries and chargers	Per substation	9% of batteries	0,090	248,00	21,00
7	Cleaning substation buildings	Per substation	Monthly	12,000	248,00	148,00
8	Painting of equipment (mini-sub, TSK, etc.)	Per equipment	1% yearly	0,100	1 566,00	1 075,00
9	Warning of consumers	Per incident	100% yearly	1,000	40,00	50,00
10	Painting of substation buildings	Per substation	20 years cycle	0,050	24,00	21,00
11	Winter load reading	Per substation	100% yearly	1,000	24,00	98,00
	Total			29,260	1 654,00	1392

Table 3: Example of resources allocation as per maintenance management plan.

financial constraints. Recently, mainly due to theft of copper or non- ferrous metals, the CoT has been extinguishing fires in order to restore power to the consumers in line with NRS 047/048. With this on record some preventative maintenance did suffer a lot and this may result in a number of brownouts if not blackouts.

Fortunatly this "phenomenon" seems evident only on the distribution network while the transmission backbone is still intact. The NERSA's D-forms that the department uses for reports show compliance despite the challenges the city faces with regards to theft. Growth also poses a huge challenge as everyone knows the SA economy is booming and electricity supply is among others a basic contributor to economic activity.

Just as with the rollout of civil construction a shortage of key materials is not an exemption in the provision/rollout of electricity services. Recently, the city encountered a severe shortage of basic materials like minisubstation and cables, thereby compromising on availability of supply index from the supply chain management/services side.

The best practices of newest technology on safe, reliable equipment also came under the spotlight. In particular OCBs and VCBs that seem to have flaws as far as safety is concerned. For an electrical distributor to have a reliable, safe, maintainable system, the CoT has learned that the following should form a basis:

- System availability index of over 95%.
- Good abnormal situation management e.g. repairs any 11 kV fault with 24 hours of fault and put to service.
- Ensure that the MMP is interactive and is modified in line with new assets being added to the network.
- A 50% asset replacement value be used as a benchmark for maintenance budget.
- Refurbishment program to be catered for e.g. a 3,5% – 4% budget for the program.
- Routine checks under preventative maintenance should be done despite all other challenges.
- A certain percentage should be collected from the tariffs for maintenance purpose. This will help and prevent national blackouts.
- The construction division should at all time communicate and work together with the maintenance division in order to ensure the maintenability of the system not be compromised.

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List of abbreviations	
Abbreviation	**Explanation**
ASA	Average Service Availability Index
BETAPLUS	Common Cause Failure Assessment
CDF	Cumulative Distribution Function
COMPARE	Calculating Optimum Maintenance Parameters
CoT	City of Tshwane
FARADIP	Failure Rate Data In Perspective
LV	Low Voltage
MMC	Member of Mayoral Committee
MMP	Maintenance Management Plan
MTTR	Mean Time To Repair
MV	Medium Voltage
NERSA	National Energy Regulator of South Africa
NRS	National Regulatory Specification
OEE	Overall Equipment Effectiveness
PLASMA	Plant Simulation Analysis
RAM	Reliability, Availability and Maintainability
RCM	Reliability Centred Maintenance
SAIDI	System Average Interruption Duration Index
SAP PM	System Application Programme Plant Maintenance
SCADA	Supervisory Control And Data Acquisition
SEC	Strategic Executive Officer
TPM	Total Productive Maintenance
TTREE	Fault Tree Analysis Software
VCB	Vacuum Circuit Breaker

Cost and performance implications of infrastructure investment options

A project is presently underway within Eskom Distribution to develop a relationship between network performance and investment expenditure. The results are expected to be used to revise Eskom Distribution network planning and design criteria, and inform future incentive based regulation mechanisms linked to capital expenditure. In light of possible future CAPEX linked incentive schemes and the Eskom Distribution drive to improve network performance, it is important that the relationship between Eskom Distribution capital investment and network performance be quantified.

by Martin Cameron, EON Consulting[1], Dr. Clinton Carter-Brown, Eskom and Deon Vrey, NETGroup

It is important that the relationship between Eskom Distribution capital investment and network performance be quantified. Eskom Distribution need to understand how much it will cost to achieve a range of improvements in network performance e.g. how much will it cost to achieve a 20%, 40% or 60% improvement in network performance and what are the most cost-effective options to achieve these improvements?

This paper focuses on the reliability modelling of a sample distribution network to determine possible levels of performance improvement and related cost implications.

The paper is structured as follows: the approach applied and software used are explained, followed by more detail on a specific test system (feeder) modelled as part of this initiative, and the results obtained and example interventions tested. The final section concludes with suggestions for future refinements.

Approach followed

The objective of the project is to understand the reliability cost relationship for the Eskom Distribution network (on a national basis). This is performed via the analysis of a representative sample of networks based on a spatial analysis considering both network characteristics and operational environments. An overview of the approach is provided in [1].

Data and modelling process

All of the Eskom Distribution feeders were categorised by applying a stratification based on a combination of network characteristics as well as the environment in which these networks operate. Feeders were stratified based on the following aspects:

- Technology (e.g. overhead or underground)
- Voltage level (e.g. 6,6 kV, 11 kV, 22 kV)
- Feeder length ranges (e.g. 11 kV: 0 - 40 km, 40 - 80 km, > 80 km; 22 kV: 0 - 135 km, 135 - 315 km, > 315 km)

Footnote

1. We would like to thank our colleagues Claudio Guidi and Guillermo Layeranza (PA Consulting), Cheryl Warren (NationalGrid) and Marius du Preez (NETGroup) for their input.

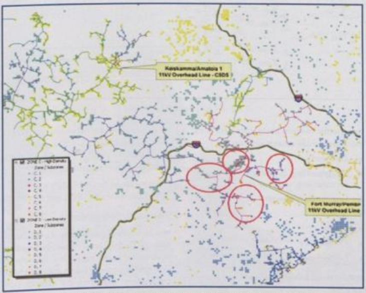

Fig. 1: Geospatial example of network and operational information applied

This information was combined with network operational environment information to account for (or modify the basic expected performance) differences in operation of the same network configurations in areas with different operational environments. The modifiers are:

- Human population combined with installed capacity. Four zones were applied:

  Zone A: (no people and no Eskom network)

  Zone B: (people and no Eskom network)

  Zone C: (high density people and Eskom network)

  Zone D: (low density people and Eskom network)
- Lightning (LI) (low, high)
- Vegetation (VG) (low, high)
- Pollution (PO) (low, high)

REFERENCE
Type 1: LI= L - VG= L - PO= L
Type 2: LI= L - VG= L - PO= H
Type 3: LI= H - VG= L - PO= L
Type 4: LI= H - VG= L - PO= H
Type 5: LI= L - VG= H - PO= L
Type 6: LI= L - VG= H - PO= H
Type 7: LI= H - VG= H - PO= L
Type 8: LI= H - VG= H - PO= H

Table 1: Modifier combination types

Various sources of information were used and processed into a spatial grid of 500 x 500 m that covers the surface area of South Africa.

This approach allowed for the classification and categorisation (see types in Table 1) of all of the Eskom Distribution feeders (in excess of 6000) based on the dominant operational environment characteristics through which the feeders pass.

Network information was obtained from Eskom's Smallworld geographic information system (GIS), supplemented with network operating diagrams (ENS / Reni) from the engineering department. This information formed the basis for the models created and applied in this analysis.

Another dataset required for this analysis is cost estimates[2] for possible interventions to improve the reliability performance of

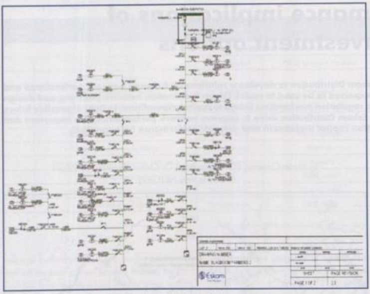

Fig. 2: Example of network diagram

Type of Network Equipment	Base Case	
	λs	MTTR
Main lines	0,19	4,00
Branch lines	0,19	3,00
Switch	0,02	4,00
Fuse	0,03	4,00
Transformer	0,09	4,00

Table 2: Failure parameters applied.

Attribute	Value
No. of customers	68
No. of transformers	66
No. of fuses	61
No. of switches	2
No. of breakers	1
11 kV line length	34,9 km

Table 3: Slagboom feeder characteristics.

Network	Value
Technology	Overhead
Voltage level	11 kV
MV length range	0 - 40 km
Modifiers	**Value**
Population capacity	Eskom low density (D)
Modifier category	3
Pollution	Low
Lightning	High
Vegetation	Low

Table 4: Slagboom classification.

the specific feeders being analysed. Cost estimates include aspects such as:

- Civil works
- Equipment (e.g. feeder bay, transformers, sectionalisers, reclosers etc.)
- Line conductor length
- Transport
- Labour
- Contingency
- External services

Reliability modelling – approach and software

In general reliability modelling is based on failure and restoration models, defining the way in which specific components and systems fail (failure rate) and what the average restoration/repair time is (repair time).

The three basic approaches to distribution system reliability modelling are [2]:

- Markov modelling (see e.g. [3]),
- Monte Carlo simulation (see e.g. [6]), and
- State enumeration.

The approach applied for this analysis was based on Markov modelling combined with state (contingency) enumeration.

Various software providers make provision for electrical distribution reliability modelling such as DISREL[3], DIgSILENT PowerFactory[4] and CYMDIST (RAM)[5] to name but a few.

The software applied in this study is DIgSILENT PowerFactory Version 13.26 and CYMDIST.

Basic assumptions applied

In order to model the reliability of a distribution network feeder certain basic assumptions have to be made regarding the network state and component failure rates. The basic assumptions regarding the network state applied in this study are:

- Networks are reasonably maintained.
- Networks are operated normally.

Two basic parameters needed for reliability analysis are:

- *λs*: Sustained failure rate – the average frequency of components faults or failures per annum.
- *MTTR*: Mean time to repair – the expected time (hours) it would take to repair a component outage and restore the system to a normal operating state.

The network components identified in the modelling were limited to major system components such as:

Fig. 3: Geospatial example of Slagboom 11 kV feeder near Ceres, Western Cape.

Footnote

2. This information was compiled by NETGroup and linked with the outcomes of the modelling process in Microsoft Excel.
3. DISREL is a computer program to calculate predictive reliability indices for an electric distribution system. See www.gri-us.com/disrel.htm.
4. DIgSILENT PowerFactory is an integrated power system analysis tool that combines reliable and flexible system. See www.digsilent.de
5. CYMDIST (RAM) is an add-on module to CYMDIST designed to aid distribution engineers in assessing the reliability of electric distribution networks. See www.cyme.com

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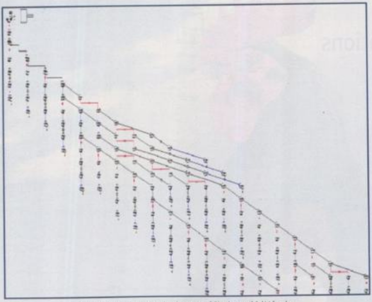

Fig. 4: DIgSILENT network schematic of Slagboom 11 kV feeder.

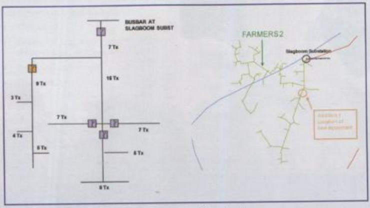

Fig. 5: Intervention 1 – additional recloser.

- Main lines
- Branch lines
- Switches
- Fuses
- Transformers

Assumed failure statistics for these components are provided in Table 2.

As mentioned in the approach, modifiers are used to assist in differentiating performance levels of similar designs across different operational environments. These modifiers are assumed to vary the reliability performance of relevant equipment (based on averages supplied by PA Consulting for the Latin-American experience) and are calculated based on the specific categorisation of a feeder. The test system, expanded on later, illustrates this categorisation in more detail.

Network performance indices need to be selected for the analysis. For the purposes of this project both SAIDI (sum of customer interruption durations/nr customers served [hours per year]) and SAIFI (nr of customer sustained interruptions/nr customers served [per year]) were used.

Test system

The information from the Eskom GIS system and operating diagrams was used to construct models in DIgSILENT for reliability modelling purposes.

For this analysis a feeder in the Western Cape region was selected, namely the Slagboom Farmers 2 11 kV feeder (Fig 3).

Table 3 summarises the basic characteristics of the sample feeder.

The Slagboom Farmers 2 feeder was exported from the GIS and imported and prepared for reliability analysis within DIgSILENT. The

Type of Network Equipment	Category D3	
	λs	MTTR
Main lines	0,24	4,00
Branch lines	0,24	3,00
Switch	0,02	4,00
Fuse	0,03	4,00
Transformer	0,09	4,00

Table 5: Failure parameters – category D3.

Measure	Base Case	Cat D3*	% Change
SAIDI	10,4	13,0	25,0
SAIFI	2,6	3,3	26,9

Table 6: Modifier impact on performance.

Slagboom_Farmers 2 feeder is represented schematically in Fig. 4.

The operating environment classification applied to this feeder is based on the approach as described in section 2.1 and summarised in Table 4.

The impact of the feeder classification (type D3 environment) on failure parameters is provided in Table 5.

Results

The potential performance of a network, while influenced by the operational environment, is mainly determined via the inherent design characteristics of the network e.g. lengths of feeders, number of customers supplied per feeder, inter-connectivity between feeders and redundancy of equipment.

These structural issues are influenced by CAPEX investment decisions, as are made via network planning and design. A well maintained and operated network can only perform as well as is dictated by its inherent design characteristics. For any given network with a set of possible maintenance interventions, there is a point beyond which additional expenditure via CAPEX solutions will result in improved performance as compared to OPEX expenditure [4].

While reliability assessment models provide insight into the existing state of distribution systems, their real value is the ability to quantify the impact of infrastructure improvement options.

Impact of modifiers

Two basic scenarios were analysed:

- The first is the basic network design without any changes or modifiers applied, called "base case",
- In the second the environmental operational classification modifiers (category D3) associated with this feeder "Cat D3" are applied.

Referring to Table 6, it is evident that the type of

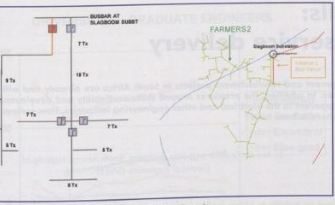

Fig. 6: Intervention 2 – circuit split.

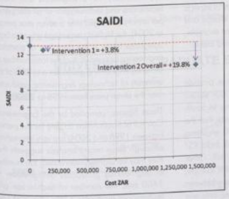

Fig. 7: Relationship between cost and reliability (SAIDI).

environment within which this feeder operates can significantly contribute to a change in SAIDI and SAIFI (in this case a change of approximately 25%). Consideration of the operating environment is hence critical when analysing network performance.

Impact of infrastructure interventions

Typical infrastructure options that a predictive reliability model can simulate include [5]:

- Line reclosers
- Sectionalising switches
- New feeder tie points
- Feeder automation
- Undergrounding circuits
- Replacement of aging equipment
- Load transfers between feeders
- New substation and substation expansions
- New feeders and feeder expansions

For illustrative purposes two interventions are proposed to improve the basic performance of the sample feeder. Simulations are performed for each intervention:

- The first intervention (IV1) is to add a recloser as illustrated in Fig. 5.
- The second intervention (IV2) is to split the circuit by adding a new feeder bay and section of overhead line as illustrated in Fig. 6.

The comparative results are provided in Tables 7 and 8.

Combining the SAIDI reliability results obtained for these two interventions with the cost estimates required for their implementation, the cost to benefit chart in Fig. 7 is plotted. The same can be done for SAIFI.

In this specific case an initial improvement of approximately 3,8% in SAIDI performance can be achieved by spending approximately R120 000 i.e. R240 000 per SAIDI hour reduction. An improvement of approximately 16% can be achieved at a cost of 12,6 times that of the first option (approximately R1,5-million) i.e. R581 395 per SAIDI hour reduction.

For the specific sample network, adding a recloser only results in a marginal performance improvement. A significant improvement in network performance requires a change in the topology of the feeder (as illustrated by intervention 2) and attracts significantly more cost.

Summary and conclusion

The paper has illustrated a reliability modelling approach followed by Eskom Distribution in order to better understand the relationship between the cost of network infrastructure improvements and the expected return on this investment in terms of improved reliability of the network.

Analysis of the sample network shows that for the particular network studied:

- The environment within which a network operates can impact significantly on the reliability of the network.

Measure	Cat D3	IV1	% Change
SAIDI	13,0	12,5	-3,8
SAIFI	2,6	3,3	26,9

Table 7: Intervention 1 impact.

Measure	SAIDI	SAIFI
Cat D3	**13,00**	**3,30**
IV2 - Line1	11,80	2,96
% Change	-9,23	-10,30
IV2 - Line2	7,34	1,84
% Change	-43,54	-44,24
IV2 - Overall	10,42	2,61
% Change	-19,83	-20,78

Table 8: Intervention 2 impact.

- Significant improvements in network performance may require topology changes.
- There is a diminishing return on investment in terms of additional improvement in reliability for more costly infrastructure investments.

Further sample networks are being studied so that the results for a range of representative networks can be used to:

- Determine the most cost-effective infrastructure options to improve network performance for different types of networks (ranging from urban cable networks to deep rural overhead networks supplying rural electrification) operating in different environments.
- Determine a relationship between network performance and cost for the entire Eskom Distribution network.

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Engineering skills: key to effective service delivery

Large and smaller infrastructure development and refurbishment projects in South Africa are already and will in the future place increasing strain on resources. In addition, the pressures around skills availability and development are increasing. These pressures are no less apparent in the electrical and other engineering industries. How serious is this situation, what impact is it having, and where to from here?

by Ian McKechnie and Stan Bridgens, South African Institute of Electrical Engineers (SAIEE)

It is now common cause that in South Africa we are faced with a chronic skills shortage in the engineering sector. We are faced with a multi-faceted problem in this respect, including factors such as:

- The historical education legacy in South Africa, where skills were disproportionally developed in the population.
- A global demand for skills in this sector, with the resultant global mobility of these skills.
- The deficiencies in the present school system and in particular the low numbers of learners with sufficient grade levels in maths and science to undertake tertiary education in the engineering sector.
- The collapse of traditional artisanal training.
- An inadequate contribution through the SETAs.

These resources and skills-related problems are reflected across the industrial and engineering sector in South Africa, confronting us with a huge international challenge, and global competition for a finite quantity of these requirements. By way of illustration, in presenting their interim results in March 2007 in Johannesburg, Sasol reported "moderate delays and increased costs" on certain of their projects, owing to a global shortage of engineering and construction resources. They provided interesting figures, citing their internal studies on some 184 projects with a value of R62-billion that would materialise over the next few years. These studies indicated that projects were likely to take some 11% longer to complete than first anticipated. Sasol CEO Pat Davies was reported as saying that a recently-released international benchmark suggested that projects indexed at a cost of 100 in 2002, came in 60% higher in 2005 and were likely to be indexed at 180 by 2008.

These same challenges are being experienced across the various engineering industries, including electrical engineering (and electrical distribution). We are faced with an ongoing exodus of skilled and experienced staff, placement in many instances of relatively inexperienced persons in positions of responsibility for which they are ill-equipped and often therefore "set up for failure", inadequate mentoring and training due to the exodus of skilled and experienced staff, and an inability to obtain (and/or attract) staff with appropriate skills and experience. This has resulted in negative effects in aspects such as maintenance, planning, design and engineering management and, for example, electrical network management and status.

Situational analysis

Comparative international figures provide an illuminating perspective on our skilled resources in the engineering sector in South Africa. Comparative figures indicate that the USA produces in the order of 380 engineers per million people, China 225/mill, India 95/mill, and South Africa about 45/mill. Other studies show that whereas Western Europe, North America, India and China have between 130 and 450 people per engineer, only one out every 3200 South Africans is an engineer, which represents between a ten and 20 times disadvantage. Consider also that a country like Taiwan, which has half the population size of South Africa, produces about ten times the number of graduate engineers as South Africa. Similarly between 30% and 46% of all graduates in China are in engineering – about half a million graduate engineers and technicians produced per year.

South Africa produced an average of approximately 1272 engineers and 2036 technicians and technologists of all disciplines per annum (averaged over a seven year period to 2004), the highest percentage group in both categories being in the discipline of electrical engineering (around 35% of the total number of university engineering graduates and 38% of the university of technology engineering graduates over the seven years from 1998 to 2004).

These figures, compiled by the Engineering Council of South Africa (ECSA) for the period between 1998 and 2004, are very interesting, although some recent analysis suggests that they may be slightly understated, the number of engineering graduates being closer to 1400 and the number of technician and technologist graduates a little over 3000 per year. Figures for subsequent years are not presently available from ECSA. Nevertheless, the following graphs are interesting:

While accurate data for subsequent years is not presently available, the trends clearly show that there are some significant challenges ahead. It has been made clear by the Department of Education and the Joint Initiative for Priority Skills Acquisition (JIPSA) task team that the level of graduate engineers

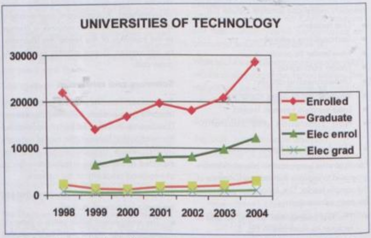


Fig. 1: Enrolment and graduation figures at universities of technology (technologists and technicians).

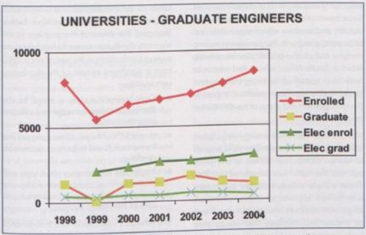


Fig. 2: Enrollment and graduation figures at universities (graduate engineers).

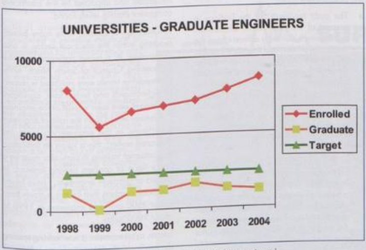


Fig. 3: JIPSA targets for universities (graduate engineers).

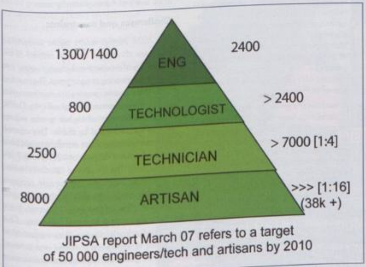


Fig. 4: Extrapolated requirements for the engineering team, based on JIPSA targets.

needs to be increased from the present levels of 1300/1400 per year to 2400 within the next four to five years. This problem is exacerbated by the crisis in engineering education where staff vacancies are at astonishingly high levels. In addition, academic salaries in the technical fields have been eroded so significantly recently that filling vacant posts, let alone urgently attracting the additional staff needed to deal with the increased student numbers, is very difficult if not completely impossible.

It is important to understand that the skills shortage is being experienced across the engineering team. In considering the composition of the engineering team, the traditional pyramidal model, comprising engineers, technologists, technicians, and skilled and unskilled artisans provides a useful insight. While shortages are experienced across the board, the base of the pyramid (the artisan level) is particularly problematic and requires urgent attention to stabilise this foundation of the resource base.

The collapse of the traditional artisan training structures has resulted in levels of artisan training dropping significantly. Previous reports have indicated numbers around 30 000 registered artisan apprentices in 1975 dropping to an estimated 3000 in 2006. More recent reports indicate that the country is producing around 8000 qualified artisans per year through the combined Indlela and SETA processes. The March 2007 JIPSA report also notes that while the economy is producing approximately 5000 (SETA) artisans per year, research indicates that at least 12 500 artisans should be produced per year over the next four years. Other indications are that this figure should be much higher as also noted in the graphical illustration below. The reported average age of artisans in South Africa at present is in the mid-fifties.

Much therefore remains to be done, particularly if one notes, for example, that in the past four years to March 2008, while the throughput of the COTT/Indlela process (for automotive eng; electrical eng; mechanical eng; service, manufact and process techn; physical planning and construction sectors) has remained largely consistent at an average of 3079 passes/annum, the pass rate has dropped consistently each year from 49% in 2004/5 to 37% in 2007/8.

If we then consider the pyramidal structure of the engineering team, and assuming we need at least as many technologists as engineers, we probably need to at least increase the number of technologists (BTechs) up to about 2400 per year (about 3 x time current 800/ annum) and the number of National Diploma graduates up to at least about 7000 per annum. If we then factor in the number of artisans required, and look at the current reported apprenticeship and production levels, the challenges are obvious.

While there are various initiatives aimed at increasing the output of our engineering team, such as the JIPSA initiative as just mentioned, the essential limitation with schemes such as this is that they will only have a significant impact over the medium to long term. Furthermore, in order to produce more engineers, technologists and technicians, it is necessary to feed more students into the tertiary education system. This means that it is critically necessary to increase the number of "qualifying students" – those with good enough school grades in mathematics and science, the right aptitudes and the right level of preparation (and of course the right committment).

It is important to understand this pipeline of engineering capacity development, and more will be said shortly. Contrary to assertions made in support of the proposed new Built Environment Professions Bill (of which engineering forms a part), professional registration is not the primary bottleneck in this pipeline in developing skills, nor is it a racist gatekeeping role as has been alleged. The statistics show that of all ECSA registrations in the past three years, 56% were PDIs. In electrical engineering, 61% of all new registrations for PrEng between January 2005 and August 2008 were PDIs.

As already noted, sufficient availability of suitable lecturers and tutors remains a significant challenge in addressing any increase in enrolment numbers and throughput.

In respect of artisans, it is encouraging that in the last few years in particular, industry has realised the need to establish retention and training programmes in order to secure the skilled resources that are required. It is also encouraging that government appears to have also realised the urgent requirements and apparent inability of existing structures to deliver the required skills base.

It is quite clear from industry reports and comments that the current SETA approach is not working in delivering the required skills and quantity of skills required in this sector, and that a compete review of the current philosophy and structure is required. Indeed, the revelations in May 2008 of large scale alleged corruption and other issues within the Energy SETA for example further serve to underscore the urgent necessity to re-evaluate the system and plot an appropriate course with industry that will address the problem in a sustainable and effective manner.

Electrical sector

The drawn-out electricity distribution industry restructuring process has created uncertainty and contributed to underinvestment in refurbishment and maintenance (and continues to do so), and particular problems related to availability and retention of skilled resources have been identified. These distribution industry problems are effectively another real crisis area, along with the generation reserve margins and plant availability issues currently faced in South Africa, and skilled resources have been identified as being fundamental issues, with a significant resultant impact in the management and status of the distribution infrastructure.

NERSA (the national energy regulator) commissioned an independent sample audit of eleven distribution utilities a few years ago and the report was completed in 2006. These sample utilities included two Eskom distribution regions or areas, and both large metropolitan municipalities as well as smaller municipalities. The results were both interesting and in the main of huge concern. To highlight a few of the results of this independent audit:

- The audit reported that the findings in respect of the two Eskom distributors audited were markedly different from the municipal utilities, and they were found to be well-run and managed undertakings. General findings included excellent and comprehensive asset management and maintenance systems, adequate funding for maintenance and refurbishment, adequate staffing at all skills levels with access to sound and competent technical expertise, and adequate resources throughout.
- In the case of the large municipal undertakings and metros, the audit found that this class of utility displays a level of robustness which can be seen to be "faltering", and commented specifically that lack of investment since the advent of the EDI restructuring hiatus was now evident. It also commented that it was increasingly evident that a dearth of skilled staff has resulted in the embrittlement of management resources and loss of control over essential technical elements such as planning and protection. The audit also highlighted insufficient investment in refurbishment and maintenance processes and continued loss of skills coupled with an increase in the average age of skilled senior staff.
- In the case of smaller municipalities, these undertakings were found to be generally in poor shape, being heavily under-resourced and stressed in the delivery of the required levels of services and the audit report noted "there is little doubt that serious customer complaints are in the pipeline". General findings also included that the networks are in a poor state of repair, staff are demotivated and often under-skilled, very few formal systems for maintenance management are in place, there is poor housekeeping and there is great reliance on individual engineers and technicians with consequent risks when they leave.

Other as-yet unpublished and more broad-ranging investigative studies have further illustrated the extent of the problem in the electricity distribution sector. To highlight some surveyed indications in the period since 2003 from a significant sample of the distribution sector utilities:

- Only approximately a third of the distribution utilities surveyed had sufficient competent staff.
- In only 15% of those utilities surveyed was the network found to be in an acceptable condition.
- Acceptable maintenance plans were only available in approximately 43%, and acceptable technical asset registers in only 23% of the utilities surveyed.

The network's operational and maintenance conditions, and the key support planning issues as noted above, are significantly influenced and impacted by the insufficient competent staffing levels found.

The situation at Eskom, while more broad-reaching within the electrical sector, is also illuminating. At a recent presentation to the Engineering Council of South Africa, while some positive trends were indicated in respect of technologists and technicians, significant challenges were seen to exist at the engineer and artisan level. Given the ratio of engineers to artisans in the engineering team (as illustrated earlier), this is surely an indication that artisanal training in particular must be a major issue of concern moving forward. In respect of graduate engineers, I have heard unofficial numbers that Eskom is down from about 3500 graduate engineers in 1998 to about 1000 today.

Eskom, as an example, is now tackling training decisively with the Eskom Academy, where the focus will be on developing on-the-job skills at all levels of the engineering team.

Challenges and constraints

The 2007 matric results again underlined the major challenges faced in respect of the availability of prospective students to enter into tertiary engineering programmes. The number of higher grade passes in mathematics reportedly increased marginally by 0,8%, while the number of higher grade passes in science decreased by 5,6%. This against reported increases in the standard grade level passes for these subjects of 12,1% and 7,8% respectively. The Minister of Education noted "with some alarm the inadequate progress in higher grade passes in mathematics and science". She added that "However, there are encouraging signs of progress. Our Dinaledi schools initiative (the introduction of centres of excellence in maths and science) must be given focused attention and support as must our priority of ensuring that every child studying mathematics and science has a qualified and competent teacher for these subjects". This latter priority is a particular challenge given the extent and teaching demands of the new curriculum.

If we consider the actual numbers in the 2007 matric results, only 25 415 students passed higher grade mathematics and 28 122 passed higher grade science, enabling them to pursue a higher technical career. Of this number, only approximately 8000 achieved a C-aggregate or higher in higher grade mathematics, which is the typical entry level for a university engineering programme. We then need to consider that not all of them wish to pursue a technical career (and are able to select any one of many degree programmes, engineering being only one), and many do not have the other necessary attributes or support to successfully start or complete a demanding higher technical course, and not all of them will eventually complete their tertiary education in engineering.

School grades are no longer considered a reliable measure of preparedness for university study and success, and school performance is becoming a less and less accurate means of measuring likely performance at university, although the problem of finding the number of school leavers with sufficient marks in the right subjects to enter the system is an even bigger problem. In their paper "Engineering Education in South Africa: In fragile good health, denial or crisis?", Hanrahan et al noted that "matriculants with symbols that formerly were considered adequate for engineering study are underprepared for engineering study. This shift is noted in the school system and matriculation examination. Good grades reflect focused training for examinations based on technique and rote-learning rather than a lasting knowledge and appreciation of the subject".

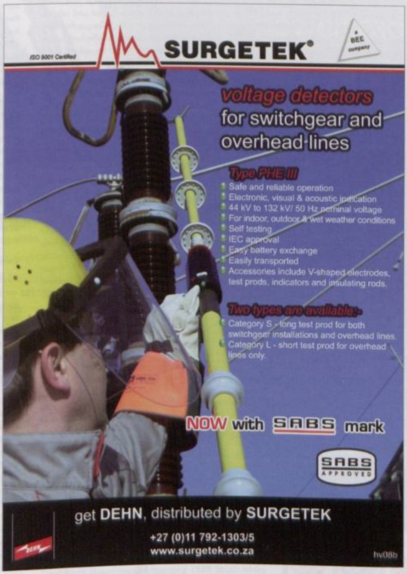
The paper goes on to also note two further factors that are dominant in determining student performance, these being the level of commitment on the part of the student given the demanding nature of engineering programmes, and more critically whether the student can afford the cost of studying.

It is therefore obvious that we need to dramatically increase the output of adequately prepared school leavers (in the broader sense, including thinking skills, literacy skills as well as actual knowledge) to feed into the engineering tertiary education system. This in turn raises questions regarding some of the changes in our school system, such as for example the discontinuing of higher grade studies, and additional mathematics. It is critical to encourage and promote (directly and indirectly) a culture of excellence and genuine achievement, as opposed to a culture of mediocrity and an illusion of success and excellence. Anything else is actually a disservice to our learners and to the needs of our country.

Further areas of concern regarding changes in the school system relate to mathematics in the new National Senior Certificate. In the first instance, the numbers of learners studying mathematics (as opposed to maths literacy) may not be as high as originally anticipated. Furthermore, as the third paper in mathematics is optional, a large number of learners may be entering university engineering programmes without having completed, for instance, geometry at school level.

The current emphasis on the achievement of an academic matric or now National Senior Certificate, and the social acceptance of vocational training versus academic education, are issues that must be urgently and seriously engaged and debated across our society, industry and government. We need to encourage our youth (and their parents) to seriously consider and take up vocational training options, for example at FET colleges, ensure through government that sufficient opportunities exist in this respect, and ensure that such education and training is appropriately valued and recognised, not as second class, but as a viable, valuable and respected education and career option.

If it is considered that the average time from



Grade 10 to the end of a typical engineering degree is eight years, with no allowance made for GAP years and other assorted activities, it implies that it takes at least ten to eleven years to produce a professional engineer beginning to be independently productive. And the time to produce a registered BTech technologist or a NDip technician is not a lot shorter. Putting it another way as an example, a learner in Grade 10 in 2008 who decides to take up engineering will (if he or she passes everything along the way and graduates in four years, which is not the average) only enter industry in 2015 and be eligible for registration as a professional engineer in 2018.

Furthermore, in considering increases in throughput and student numbers, the challenges of funding and teaching resourcing in the tertiary engineering sector are significant.

The skills shortage in the engineering and technical sector is not unique to South Africa, and is a global issue. This implies that these skills are globally marketable and sought after. Retention of existing skills is therefore a challenge requiring priority attention, as the competition to attract new skills is high. This has significant implications in terms of micro issues such as career growth and opportunities, attractions of other sectors and earnings (and therefore costs), and is significantly influenced by macro issues in the country, including quality of life and security.

Retention of skills within the engineering sector is particularly important, as the nature of the education and training received, for example problem solving and analytical skills, make technically trained people attractive to other sectors where financial and other career benefits may be better.

The shortage of skilled resources also results in supply and demand imbalances driving resource costs higher. An inability by distribution utilities to adequately address this through differentiation and an inability to pay market-related costs further exacerbates the situation.

The global nature of the skills shortage also implies that importation of skills is not an easy fix. In a report discussed in an article in Business Day on 5 March 2007, Ann Bernstein and Sandy Johnson of CDE (Centre for Development and Enterprise, an independent policy research and advocacy organisation) point out that in South Africa we face three realities:

- We operate in a global market for skills.
- We struggle with a historical legacy which developed skills disproportionately in our population.
- We are following a path of economic growth that will not be sustainable if we do not achieve an urgent and large-scale injection of skills into the economy.

In discussing the importation of skills, the report notes that despite high-level government statements that seem to accept the potential of a well-managed immigration policy to alleviate our skills shortage, these have not been followed through. The article states that in 2006 just 194 permits were granted for people with scarce skills, under a quota system that allowed for 47600.

While this throughput situation has reportedly improved in the past year, significant challenges still remain in respect of being able to import engineering and technical skills in this global situation. These include not just the processes involved, but the macro factors (the "push" and "pull" factors) that need to be addressed to make South Africa an attractive place for skilled members of the engineering sector to practice their profession or trade. Challenges in respect of issues such as cultural idiosyncrasies, language difficulties, retention of intellectual capital and relative remuneration are also all challenges that need to be addressed in order to effectively utilise skills importation as one of the options in the basket of possible solutions.

Furthermore, problems have already been encountered in South Africa in respect of imported skilled resources, and the relative standard and level of those skills. Registration or licensing of technical persons is an important issue, in respect of both direct and indirect safety issues relating to engineering personnel and the public, and general protection of the interests of the public. Problems can and have been encountered where resources are imported to be utilised in positions of technical responsibility without due consideration of these issues beforehand, where the levels of training and experience have subsequently been found to be inadequate in respect of (internationally benchmarked) South African standards or mismatched to the anticipated level of appointment (eg. technologist vs engineer), or where difficulty is encountered in verifying and/or benchmarking foreign qualifications. Maintaining standards in this respect is not "gatekeeping" as has sometimes been alleged, but is an essential reality determined by the need to protect the interests of the public and maintain health and safety standards, all in accordance with international benchmarks. While optimisation of the processes involved must be regularly assessed and enhanced as appropriate, particularly to ensure efficiency within an objective and fair framework and process, compromising standards is not an option.

Industry transformation and skills growth amongst the previously disadvantaged sector is critical to addressing the skills shortages being experienced in South Africa. It is encouraging to note ECSA statistics that in the last three years, 56% of all new registrations have been previously disadvantaged individuals (PDIs) – this in a scenario where registration is still effectively voluntary due to delays in the implementation of the identification of engineering work. The historical legacy implies that transformation growth has to come largely from the younger generation in the industry, and it is encouraging that this seems to be happening through education throughput and subsequent entrants to the industry. Certainly, our SAIEE membership demographics also reflect that this transformation process is happening at an encouraging and increasing rate.

With the ongoing skills shortage and industry demands in the engineering sector, many younger and/or less experienced members of the engineering team are finding themselves placed relatively early in their careers in positions of significant technical and/or managerial responsibility. It is important that these people are not "set up to fail" through their relative inexperience, and mentorship is a key support mechanism to assist people such as these, and indeed all younger members of the engineering team, in the successful development of their careers.

Unfortunately the demands of work commitments mean that in some organisations' senior engineering staff are stretched and unable to offer younger members of the engineering team this mentoring facility. In other organisations there may simply not be that reservoir of senior advisors and experience available. This is a key challenge that must be further addressed as a matter of urgency, through utilities and industry directly as well as through the various institutes and engineering industry associations.

Conclusions and the way forward

It is clear that much creative thought and debate lies ahead in addressing the skills resources issues and problems, particularly in the short term but also in respect of the medium and longer term, but it is equally clear that they will only be solved by all the stakeholders putting aside differences in ideological and constrained thinking, thinking "out the box", and by working towards a common vision and purpose.

Skills availability across the board is a key issue in resolving and managing the present problems throughout the electricity supply chain including at the distribution level. We need an industry and supply-chain-wide co-ordinated and realistic strategy (without wishful thinking) on skills retention, usage, development and employment. The skills shortages and skills demands in the engineering sector are not confined to South Africa – it is a global shortage and demand problem. We are therefore competing in a global market place for these scarce skills and our strategies to both retain existing skills and attract additional skills need to reflect that.

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Furthermore, organic skills growth takes time, and realistic and effective plans need to be implemented now, from the problems in the schooling system upwards into the tertiary level, and in terms of on-the-job training and mentoring.

The JIPSA approach clearly identifies three core strategies, namely to increase tertiary output, import appropriate skills and to retain current skills. The importance of the latter, to retain existing skills within both industry and the country as mentioned earlier in this document, cannot be over-emphasised. We therefore need to be cautious about the signals we send and the policies we adopt, at a micro and macro level, if we want to attract and retain these mobile and marketable skills.

Clearly there are some challenges that urgently need to be addressed now, in order to encourage and nurture an interest in, and affinity to, science, technology and engineering amongst our youth. In a recent paper prepared by Prof. Hu Hanrahan and others entitled "Engineering Education in South Africa: In fragile good health, denial or crisis?", the need was clearly identified to "get them young"! This has a significant implication for not only educators in the schooling system, but for the professional institutes and engineering industry associations and bodies, to effectively and proactively market technical careers to our youth. This implies both a direct approach, as well as in indirect approach through the effective and very visible marketing of appropriate role models in the various communities.

Addressing these educational issues is however clearly a longer term issue and potential impact. The more pressing issue is how is the country and the electrical and distribution industry sector will cope with the shorter-term demands of the infrastructure development and maintenance this country desperately needs and which government has committed itself to deliver – the demands of the next five, ten and 15 years.

As noted earlier, it is clear that we are part of a global market for skilled people, particularly in technical disciplines such as engineering, and we therefore need to compete for these globally mobile skills in a global marketplace. In South Africa, we are not a special case that can expect special considerations in this respect. As in any market, we need to sell our pull factors and we need to minimise our push factors – not just to attract additional skills to come to South Africa, but to retain those we have. And – it is indeed about perceptions (as well as the hard reality). In the same vein, this principle is applicable on a micro-basis within the industry sector as well as on a macro and country basis.

Much has been made by many commentators of the principle of affirmative action and the need to scrap the policy in order to address the skills resources and operational issues. Finance minister Trevor Manual commented on this last year after numerous calls for the suspension of affirmative action. In a rather interesting choice of words, he said that the intent of the Employment Equity act was "abundantly clear", although he said it "was sadly abused in practice". As Dave Marrs (the Cape editor of Business Day) put it in an article in March 2007: "There is no need to scrap employment equity – just apply it fairly and sensibly as was intended". He commented further that instead of being applied in a nuanced manner which includes previously disadvantaged people being given preference, but not to the exclusion of whites and without skills and skills requirements being taken into account, it has tended to become a non-subtle numbers game. This remains a challenge to be addressed.

In the electricity sector (and I suspect parallels can be identified in other engineering sectors including mining), the current trend of outsourcing within the electricity distribution (and other) sectors, while possibly being an effective short term solution, does little to empower the infrastructure owner, and enhances the risks of unreliability and failure in the longer term. Inadequate delegation of authority to outsourced consultants and companies, within the responsibility framework dictated by network operational and maintenance requirements, as well as health and safety issues (for one example as the responsible or designated person in terms of the OHS Act) poses a serious risk both to the outsourced resource and to the utility.

Furthermore, retention by the utility/network/infrastructure owner of the asset/engineering information and co-ordination and integration of the engineering activities is unlikely to be achieved because of the inherent underlying skills and resource shortages that necessitated outsourcing. It is therefore essential that electricity undertakings (and other engineering and infrastructure undertakings) have the in-house expertise to firstly manage outsourced work or services, ensure proper integration and coordinated implementation of activities including outsourced contracts, and to retain core levels of expertise and experience internally.

There is a large body of engineers no longer professionally active, or no longer active specifically in the electricity and distribution sector – the so-called "grey power". There have been some initiatives to bring them back into the private and public sector to assist younger and less experienced engineers, technologists, technicians and artisans in the short term, training them in the practical application of their skills, transferring knowledge and mentoring them. This concept and process needs to be encouraged and supported, actively marketed and made to be an attractive option.

The employment of such displaced or early retired skills is considered to be a viable option. There are however a number of issues that negatively influence this strategy, as well as the strategy of utilising outsourced skills. These include, for example, issues around relatively onerous accountabilities and responsibilities for engineers in line functions within reporting structures that are misaligned, for example in terms of authority issues or where there is a lack of understanding of the engineering or technical issues. This can result, for example, in serious misunderstanding of the impact of, or delays in making, critical engineering decisions, with resultant risks and effects in respect of health and safety, operational and/or economic factors.

Effective mentorship must therefore be seen as a critical outcome of any intervention through employment of such skills. Mentorship must be a key deliverable and performance criterion in any such intervention, and indeed must be seen as a priority focus throughout the industry in general, and the resources of professional institutions and industry associations must be more effectively mobilised. The SAIEE for example, has established a voluntary mentorship programme whereby approximately 200 members presently volunteer to make their services available as mentors. Clearly this is just a starting point in setting up a sustainable programme, but points the way to what can and should be implanted across the industry.

Bursary schemes are important in respect of addressing the economic issues impacting on facilitating skills development and learning, and the SAIEE is proud of its long established bursary scheme which has grown in the past year to the extent that bursaries to the value of nearly R250 000 were awarded, and a bursary administration service for industry companies has been implemented.

It is however an unfortunate reality that in many cases bursary schemes are ineffective in respect of the successful throughput. In a particular case study for a large municipal electricity utility over three years, 73 bursaries were offered to historically disadvantaged individuals (17 BSc Eng; 40 NDip Elect./Science; 13 Fin./Audit.; three other). Of the 57 'engineering team' bursars, eleven declined the offer or dropped out, seven have completed their three year course of study and the remaining 39 are still studying of which 17 (approximately 45%) are expected to complete their studies. In summary, of the 57 potential engineering human resources offered bursaries, only 24 (42%) will probably be available to fill the skilled resource vacancies in the engineering team within that entity, assuming they are not offered or take up positions elsewhere. It is also pertinent to note, given the related comments elsewhere in this paper in respect of mentoring, a particular and further concern expressed at this utility in their ability to properly induct and mentor these new resources after graduation due to a lack of sufficient experienced engineering resources within the utility.

Furthermore, there is growing evidence to suggest that a substantial proportion of learners entering university engineering programmes do so because of the excellent bursary support they can obtain, although their real interest is not in engineering. As a result, many of these learners drop out, often after a few years in the programme.

The SAIEE has also noted a concerning decline in bursary applications received, from over 1500 applications in 2005 to around 50 for 2008. A declining trend in academic quality of applications has also been noted and indications from informal enquiries indicate that this is not a unique experience within the engineering sector. Clearly an intensive study of the bursary environment, and establishment of the key success factors and negative influences is required to effectively enhance the prospects of success for bursary students, particularly for students from less privileged and disadvantaged backgrounds.

The issues and problems around the learnerships that have replaced the traditional apprentice training must be urgently addressed. Particular issues include:

- Appropriate entry standards, coupled with effective application of aptitude testing, to enhance the probability of success and increased throughput.
- Establishment of appropriate and effective measurement standards. Industry sector feedback has indicated that the unit standards required cannot be effectively assessed in the workplace, and are also not applicable to some specific applications (distribution maintenance has been one example raised), requiring further development of customised training. While such additional training is probably a generic requirement regardless, industry feedback is that the current situation is not effective. As an example, a particular case study at a major electricity distribution undertaking revealed that after ongoing attempts to make use of the relevant SETA skills product, this effort has been disbanded and a set of 20 incumbents is now being trained in-house.

Speculation that government is considering reviving apprenticeship training schemes as previously implemented are therefore encouraging. It is quite clear that a complete reassessment of the current approach and SETA structures is urgently necessary.

It is clear that the development of solutions to the skills crisis is a complex issue, demanding urgent and coherent strategic planning by government and industry, together with the educational and training sector.

But we should end on a word of warning: unless we can address the skills crisis, and by extension address the staffing and infrastructural inadequacies at many of our institutions of higher learning, we are likely to lose the few dedicated educators we have. We will then most certainly not be likely to attract any others. This is a matter of national importance.

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Skills development for network planners in Eskom's distribution business

The current skills base in Eskom's Distribution Network Planning environment is strained with high staff turnover and a lack of sufficient training programmes for the network planners. The only form of training that is available is scattered classroom-based training which makes it difficult for the staff to attend development courses in their quest to "Sharpen the saw" (the Seven Habits of Highly Effective People - Steven Covey).

by Sanjian Malapermal, Eskom

The gap in the ability to deliver effective on-demand training has introduced the need to develop a "blended learning" solution. Blended learning incorporates the most efficient and effective combinations of learning delivery methods. From traditional classroom-based learning to the modern e-learning or web-based learning that can be accessed via a learning management system (LMS) such as the MyLearning system currently in use by Eskom. The intention of the online training is to skill the newly appointed network planning engineers to a competence level required to effectively perform their job function.

E-Learning is a relatively new concept in engineering within the Eskom distribution network planning environment. The system allows an individual, "the prospective learner" to log onto the LMS and to either self-enrol or be pre-enrolled for a specific course within the distribution network planning environment.

In order to assist the learner and to create a logical flow to the courseware, from an instructional design perspective, the course is modularised to enable learning in modular sections. The training programme covers the contents of each of the standards and guidelines for Network Planning under the Technical Steering Committee of Distribution (TESCOD).

At present the network master planning and network development planning methodology course has been developed. In future a set of 20 modules will form part of the network planning training programme that will be available to all Eskom staff. Access to these modules can be made available to the members of the AMEU.

This paper provides an overview of the network planning modules to be developed on MyLearning.

The Industry Association Resource Centre (IARC), positioned under the sustainability and innovation department within the corporate services division of Eskom Holdings Limited is committed to supporting the Eskom distribution division and the electrical supply industry at large. This is made possible by a team of industry-experienced resources that collectively have myriad years of experience, knowledge and skill to provide technology support and development to the distribution industry.

The network planning technology development team, located in the Power Plant section of IARC is responsible for technology development and standardisation of the more than 120 Eskom Distribution network planners spread over South Africa.

The six Eskom distribution network planning regions are responsible for the strategic development of the distribution network to ensure its sustainability into the future, from both an electricity demand and network reliability perspective.

The regional distribution network planning sections have experienced high staff turnover that has highlighted the need for concentrated distribution industry training in a multi-delivery approach. This need has led to the development of a network planning training framework that identifies the principles of the training which in turn initiated a research funded project to roll out technical training for the distribution network planners on an e-learning platform.

Benefits of e-learning

In order to ensure ongoing development of Eskom's human capacity in the network planning environment, a three-tiered learning approach was adopted which enforces e-leaning with the virtual classroom and the facilitated training that completes the blended learning environment. This approach is represented in Fig. 1.

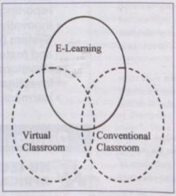

Fig. 1: The blended learning solution.

The development of the distribution technical training programme for the network planning engineers is designed to address:

- The current skills gap
- High staff turnover
- Succession planning
- Skills and knowledge transfer
- Skills building and capacity planning
- Demand for higher skilled staff
- Need for standardisation of training

The training framework

The training framework was commissioned under the guidance of the Planning Study Committee, chaired by Dr. Clinton Carter-Brown. The framework identifies 12 major learning areas, namely: distribution engineering (basic principles), distribution planning, load forecasting, distribution economics, transformers, lines, cables, power systems, distributed generation, power quality, reliability and protection.

The Planning Study Committee (PSC) consists of working group leaders, national advisors and corporate consultants. The PSC oversees and directs the working groups on the activities and deliverables required to support and develop technology enhancements within the distribution planning environment.

The working groups are responsible for the following functional areas within network planning, namely: network master planning, geo-based load forecasting, distribution philosophy, network reliability, financial and economic evaluations, cost of supply, planning tools and integration, business planning model, electrification, project prioritisation, asset utilisation, embedded generation, planning training and standards.

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- The supply, installation, testing & maintenance of high voltage and extra high voltage substation apparatus for service voltages of up to 765 kV including current transformers, capacitor voltage transformers, line traps, specialised tuning, current limiting, balancing and earthing reactors, circuit breakers, disconnectors, tubular busbars and insulators.
- HVT is a preferred supplier to Ekom in the installation of both strung and tubular busbars and the stringing/interconnection of apparatus (including control cabling) which make up switching bays.
- HVT recently entered into the business activity of on-site condition testing and maintenance servicing of all apparatus types. HVT employs highly experienced technicians who are well equipped with the latest technology instruments and can travel at short notice to any site in order to fault find or condition test and report on shunt & series capacitor banks, power transformers (including Tan-Delta loss field testing, instrument transformers, disconnectors, circuit breakers and substation earthing systems.

HVT is now located in a modern office & warehousing facility in Sunderland Ridge, Centurion and employs more than 110 experienced permanent staff members who are fairly representative of the cross section of modern day South African Society. HVT's workforce is equipped with a fleet of modern heavy transport vehicles, many of them fitted with heavy duty Jib Cranes and travel in late model LDVs. Our teams are equipped with the best tools, personal safety gear and mechanical & electrical test compliance instruments. All HVT site crew are first aid certified and are authorized to perform tasks in Eskom high voltage substations.

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E-Learning

The working groups are tasked with developing national guidelines and standards to support the above-mentioned functional disciplines within network planning. The core outputs of the initial training development will concentrate on the guidelines and standards that will be developed on the e-learning platform.

The aim is to develop e-learning courses for each of the network planning standards and guidelines as described in the following section. A high level overview of each of the standards and guidelines are provided to give the reader insight into the content of each of the e-learning courses.

Distribution technical training programme

Network master planning and network development planning methodology

The Eskom distribution methodology for network master plans and network development plans [1], details the process and data sources that are required when compiling network master plans and network development plans. This process is particularly important in light of the requirements of the distribution network grid code and the South African grid code. Network planners are required to use this process as a reference to ensure that all required information and subject matter is documented. The main activities of the process are summarised as follows:

- Study objective and review of study area
- Gather and verify network and load information
- Compile load forecast and strategic study
- Analyse existing network capability and define problem statement
- Identify and evaluate alternatives
- Capital plan and financial evaluation
- Reporting, approval and project initiation

Network planning reliability guideline

The network planning reliability guideline [2] recommends network planning criteria to improve the overall network reliability as influenced by network planning decisions. The guideline focuses on HV and MV network planning performance areas such as flexibility, reliability, availability and network capacity to improve the medium- to long- term continuity of supply of the Eskom Distribution network. It recommends minimum network criteria for network planners thereby providing trigger points for investigating alternatives to reduce customer exposure to network faults. This in turn is aimed at reducing the duration of network faults and thereby improving the performance of the network.

Medium voltage underground cables for planners

The network planning guideline for medium voltage underground cable systems [3] has been prepared in order to introduce a guideline for the planning of medium voltage underground cable networks in Eskom Distribution – with specific focus on the secondary distribution network configuration. Due to the relatively high costs of installing underground cable systems and the expected improved network performance in comparison to overhead lines, it is essential that the growth and expansion of cable networks is planned and implemented based on a defined and consistent philosophy. Medium voltage networks constitute up to 25% of the investment cost in the supply of power to customers in Eskom. Growth of underground cable networks on an ad hoc basis results in networks that are complex and sometimes over or under-designed. This results in higher probabilities of equipment and system-related failures than is necessary – compromising the customer's quality of supply.

The guideline for medium voltage underground cable systems assists network planners in optimising both the long-term capital expenditure and the overall network performance – in support of customer quality of supply, network connectivity and operational flexibility.

Geo-based load forecasting

The geo-based load forecast guideline [4] provides insight into important principles and theory underlying a load forecast and provides a practical perspective on application within the Eskom environment. The main concepts of geo-based load forecasting are as follows:

- The network planning process
- What is geo-based load forecasting?
- Important load forecasting concepts/ issues
- Load forecast methods
- Load hierarchy summation

Network planning guideline for lines and cables

The network planning guideline for lines and cables [5] provides the Eskom distribution network planner with a basic understanding of the theory and practical application, such that lines/cables can be modelled in power system analysis software (specifically Reticmaster and Power Factory) and new line/cable sizes can be selected based on minimum requirements and lifetime costs.

The location and size of future MV and HV overhead lines and buried cables is an important component of distribution network planning. Network planners need to understand the basic theory and relevant Eskom Distribution standards and specifications relating to lines and cables. They also require guidance on the modelling of lines/cables in network simulation software. Network planners need to be able to select line/cable sizes such that minimum requirements (thermal limits, fault level rating and voltage drop) are met while also minimising capital cost and the lifetime cost of technical load losses.

Medium voltage step voltage regulators

The medium voltage step voltage regulators guideline [6] provides distribution network planners with the theory and tools to model and evaluate MV step voltage regulators. The guideline contains information on how voltage regulators operate, how they should be modelled in power system simulation tools, when they should be employed and how they respond to factors such as load steps, motor starting and load unbalance. Via application of the guideline, distribution networks containing voltage regulators can be accurately and easily modelled in a uniform approach, ensuring accuracy and consistency. The guideline contains six sections, viz.:

- Theory of voltage regulation and voltage regulator operation
- Step-voltage regulator technical information
- Considerations when evaluating regulators in networks
- Specifying voltage regulators
- Modelling voltage regulators in Reticmaster (including demo and example cases)
- Modelling voltage regulators in DigSilent Power-Factory (including demo and example cases)

Network planning guideline for MV shunt capacitors

The network planning guideline for MV shunt capacitors [7] covers both the theory of operation and practical modelling of MV shunt capacitor banks, such that shunt compensation can be evaluated as part of the overall distribution planning, design and optimisation process.

The guideline is focused on the application of MV shunt capacitor banks to overhead MV distribution networks i.e. shunt capacitors installed along overhead MV feeders, and not in sub-transmission substations. Many of the principles are however also applicable to sub-transmission reactive power compensation.

Network planning guideline for transformers

The network planning guideline for transformers [8] provides the Eskom distribution network planner with a basic understanding of the theory and practical application, such that power transformers (HV/HV, HV/MV, MV/MV and MV/LV) can be modelled in power system analysis software (specifically Reticmaster and Power-Factory) and new transformer sizes can be selected based on minimum requirements and redundancy criteria.

The location and size of power transformers is an important component of distribution network planning. Network planners need to understand the basic theory and relevant Eskom distribution standards and specifications relating to power transformers. They also require guidance on the modelling of transformers in network simulation software. Network planners need to be able to select transformers such that minimum requirements (thermal limits, fault level ratings and vector group compatibility) are met whilst also ensuring the redundancy requirements are complied with.

Distribution planning standard

The distribution planning standard [9] is aimed at equipping the network planner with information required to understand the network planning philosophy within the Eskom distribution environment. The document consists of three sections that describe the network planning philosophy, external regulatory standards and the internal IARC standards and guidelines. The external regulatory standards act as drivers "pushing" the network planners to ensure technical and financial governance. The the internal drivers such as the IARC planning guidelines and standards "pull" the network planner towards a standardised approach when dealing with the capital investment and the expansion of the distribution power system.

The planning criteria section in the document assists in the interpretation of the technical requirements when expanding the power system. The impact of new customers on the existing network and the associated power quality requirements is dealt with in the quality of supply section.

The application guide section references the planning standards and guidelines that will assist the network planner with the understanding and implementation of the network planning philosophy and ensure compliance with regulatory requirements.

The concluding section of this standard summarises in the annexure the South African grid code and the distribution code to enable an understanding of two of the external policies that influence the decisions and the thinking of the distribution network planner.

Network planning guideline for financial evaluation of projects

The network planning guideline for financial evaluation of capital projects [10], documents the parameters and process of using the financial evaluation model (FEM) application. The FEM is used to determine the financial viability of projects considering the capital, operating and maintenance costs and sales revenue.

Network planning guideline for voltage technology and phasing

The network planning guideline for voltage technology and phasing [11] covers the theory, standards, software modelling and selection of MV and LV network technologies for Eskom distribution network planning. The technologies include three phase star (4-wire), three phase delta (3-wire), phase to phase, single wire earth return (SWER), single phase and dual phase.

The guideline provides the Eskom distribution network planner with a basic understanding of the theory and practical application, such that both balanced and unbalanced distribution (MV and LV) networks can be modelled in power system analysis software (specifically Reticmaster and Power Factory) and that appropriate voltage levels and technologies are selected for new networks and network upgrades.

Network planning guideline for electrical motors

Network planning guideline for electrical, motors [12] covers potential problems that may

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occur when connecting large electrical motors to an electrical network, while also addressing application considerations required to model electric motor starting in a load flow simulation package. The main topics discussed are as follows:

- Basic theory of induction machines
- Motor starting
- Power quality
- Application guideline
- Modelling motors in PSA software
- Worked examples

Network planning guideline for business planning

The distribution business plan is the outcome of a development plan approval/network development plan that has been filtered through the project prioritisation model. All projects identified within a five year period are identified and updated annually. The business plan is required to inform the distribution business of the required funding for future investment in order to develop the distribution power system. This plan is used by the divisional capital programme and the tariff planning in line with the cost of supply methodology to provide for future funding.

Network planning guideline for project prioritisation

A project prioritisation model has been developed and assists the network planner with the ranking of projects in order of highest priority based on certain distribution investment criteria. This model is implemented as a MS Excel tool.

The network planning guideline for project prioritisation aims to document the national and regionally accepted approaches to support the prioritisation of projects, providing direction principles to be used when ranking projects for the various business categories of capital expenditure.

Network planning guidelines for embedded generation (EG) connection to the distribution network

- Fundamental system studies: the guideline documents basic theory, effects of EG on the networks, core issues for power flow and systems studies and connection schemes of EG to the distribution networks.
- Steady state case studies: the guideline illustrates the application of case studies for the embedded generation planning guideline.
- Advanced system studies: the guideline will cover complex system studies for inter-connecting embedded generators to the Eskom distribution network.
- Embedded generation information: The guideline will document a master type library containing generic generator information needed by network planners to model embedded generators for power systems simulation studies.

Network asset cost of supply methodology

The network asset cost of supply methodology [16] describes the methodology for performing the regional cost of supply exercise to determine the reduced network diagram (RND) and network replacement cost table (NRCT) that form an input into regional tariff design.

Distribution voltage regulation and apportionment limits

This standard [17] provides maximum voltage variations and voltage drops in high voltage (HV), medium voltage (MV) and low voltage (LV) networks, so that these limits can be used for the planning, design, operation and optimisation of Eskom's distribution networks. It includes transformer voltage control and tap settings.

Network planning guideline for electrification plans

The guideline [18] focuses on the process of information between electrification planning and network planning. The process involved is initiated by a demand side plan for electrification connection. The demand side plan is transformed into a supply side plan and results in an electrification plan through the release of a development plan approval (DPA) and a concept release approval (CRA). In order to secure an understanding of this process, the network planner and electrification planner must have a thorough understanding of the electrification process as documented as part of the capital investment process in the distribution business.

Development of the e-learning material

The above standards and guidelines will form the basis of the e-learning courses and represents the suite of training that will be available to network planning engineers in order to accelerate their development.

The process of converting the baseline material represented above into e-learning material is best described by the "analysis, design, development, implementation and evaluation" (ADDIE) model.

Analysis phase

The analysis phase seeks to study the contents of the learning material; proposes a learning solution or a curriculum; proposes the type of assessment required to evaluate the learners' understanding of the subject; evaluate the target audience in terms of demographics e.g. language and academic background. This phase identifies the stakeholders and subject matter experts and must highlight the risks associated with factors that could possibly delay the delivery of the training initiative.

Design phase

The design phase relates to the technical structure, sequence and flow of the content. This phase ensures that the organisational structure of the course is segmented into bite size learning sections, not to present cognitive overload of information. This phase is also concerned with the type and delivery of the material to ensure that voice and bandwidth are sufficient from an information technology infrastructure perspective. All aspects of the course are dealt with from the look and feel of the information to the presentation of help functions and course navigation. The colour of the interfaces, sequencing of text and pages, images and animation and interactivity is concentrated on during this phase. The aim is ultimately to ensure that information is presented and displayed in a skilful way to ensure that learning takes place.

Designing the course involves the use of assessments in order to assess or determine if understanding and learning has actually taken place by the learner. As part of the MyLearning environment, there is a specialised assessment engine or tool known as QuestionMark Perception (QMP), whose sole purpose is to design and deploy assessments, questionnaires and surveys related to the course. In this way the system can evaluate the correctness of an answer and provide encouragement where the answer is not correct and a success status when the answer is correct. This tool can also be used to conduct statistical analysis around a specific question. In this way, valuable information can be extracted and this can influence the training content through course enhancements. If a need arises for specialised interventions such as workshops or seminars to handle specific areas where learners have not done well, then the QMP tool can provide information to support these initiatives.

Other more interactive methods of stimulating learning can be achieved by the use of a mentor or coach that assists the learner in activities that are used as "gateways" within the programme prior to proceeding to the next level of learning.

The design phase, also known as instruction design is a critical output as it contains the blue-print for the course. Approval by the subject matter expert (sme) is critical in this phase to avoid the "sleeping sme syndrome".

Development phase

The development phase is purely an operational stage that follows the instructional design laid out in the design stage. This phase uses a sequence of story boards to represent each and every transition of the elearning content. It is at this stage that images, animations, illustrations and assessments are drawn, written and compiled as laid out by the instructional designer during the design phase. It is at this phase where each module and component is put together to create the actual course.

Implementation phase

The implementation phase focuses on the

deployment strategy for the course. During this phase, emphasis is placed on the learner and manager. The common question asked is "How will the learner, mentor and manager access and experience this?" There are multiple ways to deploy the solution and the most appropriate route needs to be chosen. This phase also looks at the migration of the training course and programme from the test environment to the production environment. This phase supports the sign-off of both the system and content that was approved by the subject matter experts during the design stage. The working groups have agreed to allow the distribution technical training programme to undergo two testing levels before it is rolled out to the distribution planning fraternity. The first user test comprises the working group evaluating the live course and the second user test ensures engagement of all the network planning senior engineers to evaluate the course. This two-pronged approach is aimed at ensuring that the working group members, who will become the regional mentors and the senior engineers, will serve as first-line subject matter support are given an opportunity to evaluate the course contents and system before the network planning fraternity is scheduled on the training.

Evaluation phase

The evaluation phase seeks to evaluate the effectiveness of the training. This is achieved through online questions that are posed to the learner, whereby feedback is tracked and banked for future improvement. It is at this stage that progress and performance reports are drawn. These reports relate to both learners as well as the course owner. This phase assists in determining what change management initiatives need to be triggered to assist learners as they take up the course. Being a new concept, learner support and encouragement is critical.

Conclusion

At present a number of modules are under development with a plan to develop 20 modules over a three year period. The program is focused on Eskom distribution; however, the material can also be made available to the electricity delivery industry.

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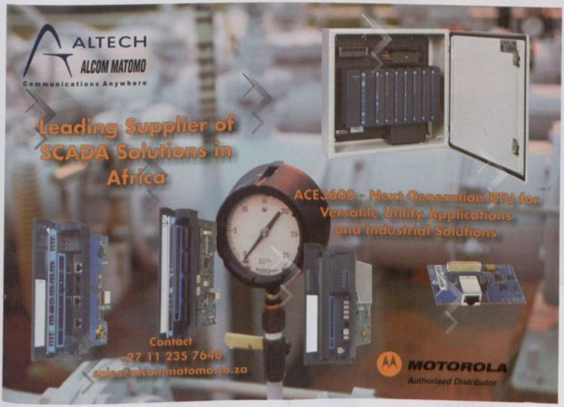

Corporate services industry association resource centre

A faulty 22 kV/400 V 100 kVA pole-mounted transformer needed to be replaced and upgraded with a 200 kVA transformer. Arrangements were made for a contractor to carry out the replacement of the transformer. Eskom was to ensure that the work site was safe prior to the commencement of work, supervise the change-out of the transformer and then to energise the new transformer, i.e. carry out operating.

by Colin Smith, Eskom

Definitions

- Definition of operating: Switching, linking, safety testing and earthing.
- Work permit form: A printed form containing the application where applicable, work permit and clearance for the authorisation of all work to be done on apparatus.

Incident recall

The deceased, an unauthorised senior technical officer (STO), was tasked to change a faulty transformer and replace it with a larger 200 kVA transformer.

He arranged with an electrical contractor to change the transformer for him on 6 June 2008.

The authorised person in charge of operating on the day of the incident also had to attend to three other outages and allowed the STO to carry out the operating under his supervision.

In his haste to attend to all the required outages he failed to apply working earths for the contractor after isolating the line as per the Network Management Centre (NMC) operating instruction.

He left the STO in charge to supervise the contractor in replacing the transformer, but did not put him on a work permit as is required.

On completion of work, the contractor left site and the STO went to other call-outs while waiting for the authorised operator to put the line back to normal.

The authorised operator had completed his shift and handed over the line via the NMC to a second authorised operator to commission the new transformer.

The second authorised operator was unhappy with the quality of the upgraded transformer installation and made NMC aware of this, but he energised the transformer and left site. Voltages on the 400 V side of the transformer were not checked.

Later that day the STO came back to the transformer site and found that the voltage was low on the 400 V side of the transformer. Instead of waiting for an authorised person, he operated/opened the drop-out fuse links by means of a link stick without obtaining permission from NMC.

A community leader stated that the STO struggled to hook one of the fuse links back into the carriage because the unit was skew.

The STO climbed up the structure using an extended ladder and positioned himself on the transformer platform without using/wearing a fall arrester system. i.e. he did not secure himself to the structure.

He attempted to hook the fuse link into the carriage using his bare hands while on the transformer platform and made contact with the bottom (transformer side) of the fuse link. He was electrocuted and fell to the ground

The community leader called another Eskom employee and asked him to call an ambulance.

The senior supervisor immediately went to the scene where he found the STO lying on the ground; the stepladder was against the pole

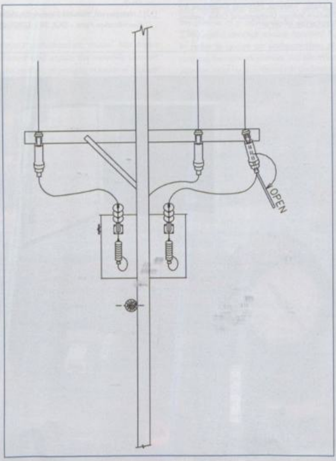

Fig. 1: Pole mounted transformer.

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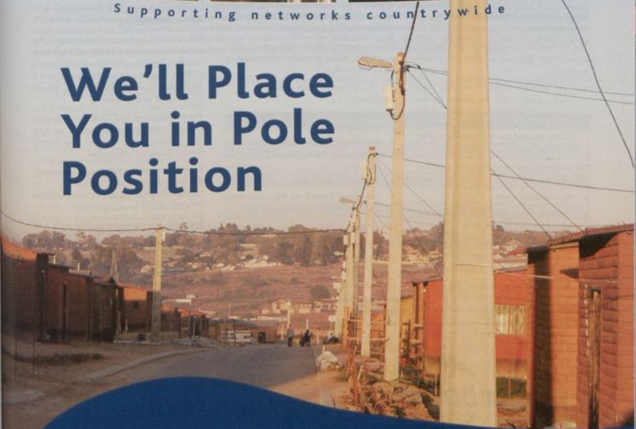

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and the link stick fully extended and against the structure. One link was open and the other two links were closed. The latch pin on the OCTS was broken.

Paramedics later arrived and certified him dead on the scene of the incident

Facts obtained from the incident investigation

The contractor employed to change the transformer did not conform to Eskom standards.

- The quality of workmanship was substandard in that the jumper for the drop out fuse link directly on top of the transformer was too short; therefore pulling the link unit and causing it to be in a skew position.

The authorised person in charge of operating did not:

- do a risk assessment
- complete the workers' register before the commencement of work, and;
- left the STO in charge to supervise the contractor while replacing the transformer, but did not put him on a permit.

The senior supervisor assigned the duty of changing the transformer to the STO who was not competent for that task.

The STO was authorised for

- low voltage work,
- a responsible person to supervise work,
- receiving permits for all work.

The STO was not authorised to work on MV networks, but was given activities to perform on MV networks and was given the accountability to ensure that supply was back.

He was required to supervise line construction work without having received any formal training in line construction.

The STO, in contravention of Eskom regulations:

- performed unauthorised operating by applying earths,
- performed unauthorised operating by opening and closing the 22 kV drop out fuse links,
- climbed a live structure,
- positioned himself on the transformer platform without using/wearing FAS

Basic causes

The TSO performed unauthorised operating. He climbed a live structure and attempted to close a 22 kV link by hand.

His level of competence did not allow him to recognise that the link was in fact live from both sides.

Root causes

There was a shortage of required skills at the depot.

The senior supervisor allocated work to the STO which he was not skilled or authorised to carry out.

Recommendations

The competency and understanding of the authorised operator in respect of the Eskom operating regulations for high-voltage systems (ORHVS Regs) should be re-assessed; and if need arises from the assessment, he should be re-trained and re-tested.

The application of the ORHVS regulations in regard to making apparatus safe to work on and earthing by the operators and control officers should be investigated.

Regional management should investigate the lack of skilled staff at Petit TSC and appropriate action should be taken to address the problem with immediate effect.

Regional management should look into the senior supervisor's leadership and management skills and put into place the necessary intervention to support his shortcomings.

The breaching of the cardinal rules to be dealt with in accordance with Eskom's procedures.

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Zambian utility experiences two failures of circuit breakers

The Copperbelt Energy Corporation is an electrical transmission and distribution company operating in the Copperbelt Province of Zambia. We supply a total load of approximately 550 MW to the copper mines and 250 MW for other industries and domestic use. We operate an electrical network comprising 220 kV, 66 kV and 11 kV substations, transmission lines and associated switchgear. Of the 433 circuit breakers that we maintain and operate, eighteen 66 kV circuit breakers are the SB6-72 SF6 type manufactured by Nuova Magrini Galileo (NMG), now Siemens S.p.A. of Italy.

by John O Silweya and Emmanuel Sampa Katepa, Copperbelt Energy Corporation

On 2 August 2007, one of the SB6 – 72 66 kV SF6 circuit breakers failed while it was being taken out of service for routine maintenance at Mill substation. The blue phase interrupting column of this circuit breaker was ruptured approximately one minute after opening the circuit breaker. This circuit breaker was installed and put to service on 30 January 2004.

On Sunday 10 August 2008, we experienced another failure of a SB6 – 72 66 kV SF6 circuit breaker at Luano switching station when the feeder on which it is installed was de-energised to allow a high load to pass under the line. The blue phase interrupting column completely shattered approximately 30 s after de-energising the transmission line concerned. In this case, when the abnormal load (truck) was passing under the line, there was a flashover when the truck got near to the blue phase conductor, resulting in the snapping of the conductor and catastrophic failure of the circuit breaker. This circuit breaker was installed and put to service in April 2003.

There were no injuries or fatalities as a result of the two incidents. The aim of this paper is to share our experiences of these failures and some of the actions we are taking to prevent these failures and ensure the reliability of these circuit breakers for continued use on our 66 kV transmission network. This paper also aims to solicit ideas on any two further actions and learning points that can be derived from technocrats in the industry who may have had similar experiences.

Equipment details

The breaker at Mill Street substation is on a 5 km 66 kV line with a calculated fault level of 19,7 kA at the Mill 66 kV busbar. Average loading on this line is 400 A, and is mainly three phase mine load. The environment is heavily polluted with dust and acidic fumes.

The Luano Substation breaker is on a 38 km, 66 kV line with a fault level calculated at 5 kA at the point of fault along the 66 kV line. Average loading is 300 A, and is mainly three phase mine load. The environment is fine with no pollution, though the area experiences high lightning activity in the rainy season (November to April). The nameplate details for the two breakers are as follows:

	Circuit breaker at mill	Circuit breaker at Luano
Make	Merlin Gerin	
Current rating	800 A	
Voltage rating	72 000 V	
Serial number	20000 1855	DIJ 1999 0049
Type	SB6 72	
Rated impulse voltage	325 kV	
Frequency	50 Hz	
Rated short circuit breaking current	78 kA	
Short term current	31,5 kA for 3 s.	

Table 1:

Mode of operation – breaking principle

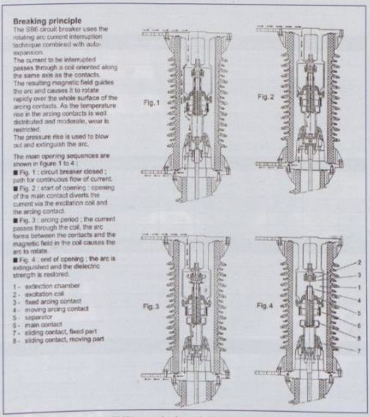


Fig. 1: Merlin Gerin SB6 – 72 SF6 gas insulated circuit breaker Instruction Manual 5 482 482 – D.

Service history

	Circuit breaker at mill	Circuit breaker at Luano
Date commissioned	Jan 2004	April 2003
Number of circuit breaker operations	372	392
Number of fault clearances	5	44 (mostly due to lightning)

Table 2:

Circuit breaker maintenance history

SF6 circuit breakers are inspected and tested annually. The tests are primarily insulation resistance and contact resistance tests. Additionally, there are quarterly trip tests to confirm the operational availability of the entire protection set-up, from the relays to the circuit breaker.

Timing or motion tests are often only done at commissioning or when due to a defect or as a result of work on the breaker mechanism, if it is suspected that there may be a potential failure in the mechanism.

Both of the failed breakers had 100% compliance to this test regime and the recorded results are presented in the tables that follow.

Circuit breaker at Mill substation

Insulation Resistance 0 CB Open [GΩ]									
	2004			2005			2006		
	RΦ	YΦ	BΦ	RΦ	YΦ	BΦ	RΦ	YΦ	BΦ
U - E	48	45	45	20	19	30	≥69,5	≥69,5	≥69,5
L - E	69	70	70	16	18	15	≥69,5	≥69,5	≥69,5
U - L	70	70	70	23	24	26	≥69,5	≥69,5	≥69,5

Contact Resistance CB Closed [uΩ]			
	RΦ	YΦ	BΦ
2004	25	26	23
2005	19	16	12
2006	92	92	94

Table 3:

Circuit breaker timing tests						
Year	Opening time [ms]			Closing time [ms]		
	RΦ	YΦ	BΦ	RΦ	YΦ	BΦ
2004	29,6	29,8	29,7	59,8	59,7	59,7

Table 4:

It must be noted that the insulation level varies due to the level of dust pollution that affects the circuit breaker outer porcelain rain-sheds/insulators.

Circuit Breaker at Luano switching station

Insulation Resistance - CB Open [GΩ]															
	2003			2004			2005			2006			2007		
	RΦ	YΦ	BΦ	RΦ	YΦ	BΦ	RΦ	YΦ	BΦ	RΦ	YΦ	BΦ	RΦ	YΦ	BΦ
U-E	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505
L-E	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505
U-L	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505	≥505

Contact Resistance - CB Closed [uΩ]			
	RΦ	YΦ	BΦ
2003	25	30	33
2004	24	35	41
2005	39	42	35,6
2006	40	42	37
2007	39	43	38

Circuit Breaker Timing Tests						
Year	Opening Time [ms]			Cloing Time [ms]		
	RΦ	YΦ	BΦ	RΦ	YΦ	BΦ
2004	29,6	29,8	29,7	59,8	59,7	59,7
2007	30,5	30,1	29,9	59,9	60,1	60,2

Table 5:

The opinion of the authors is that these results were not sufficient to predict the type of failures that were experienced.

Description of failures

Mill substation – incident of 2 August 2007

The blue phase of the 66 kV circuit breaker interrupting chamber was shattered, with the fixed contact assembly left hanging on the flyover conductor (see picture in Appendix 2). The other phases' columns remained intact.

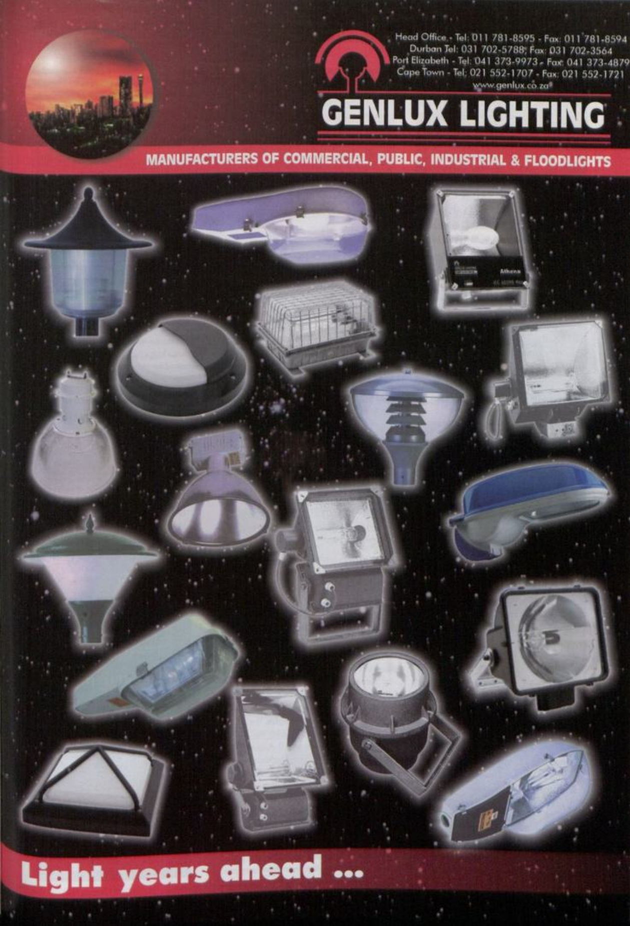
The porcelain pieces resulting from the circuit breaker disintegration were spread over a wide area in the substation HT yard. One of the flying porcelain debris hit the HT yard wall fence and broke one of the slab blocks. However, the adjacent electrical equipment did not sustain any damages.

No loss of supply was experienced by any of our customers as a result of this incident.

Luano switching station – incident of 10 August 2008

The Bancroft No. 2 66 kV line SF6 circuit breaker at Luano switching station had completely shattered.

The flying porcelain debris from the circuit breaker damaged post insulators for the Bancroft No. 2 66 kV line isolator, Solwezi line isolator, Solwezi line main and reserve bus bar insulators and the conductors to transformer 2 66 kV main bus bar isolator. The flying porcelain debris from the circuit breaker also damaged insulator discs for the bus bar flyovers on the Bancroft No. 2 and Solwezi 66 kV line bays. In addition, the red phase VT on the Bancroft No. 2 66 kV line had an oil leak and cracked porcelain from the flying debris. The blue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phase VT on an adjacent line bay was also affected and had an oil leak.

The Bancroft No. 2 66 kV line SF6 circuit breaker interrupting columns and support insulators were completely shattered (see Appendix 3). The blue phase assembly components i.e. fixed and moving contacts were found on the ground. The red and yellow phase fixed contact assemblies were still attached to their respective bus bar fly over conductors.

Circuit breaker and line earth switch control cables were damaged as a result of the explosion.

It was evident that the blue phase suffered the explosion and the yellow and red phases suffered consequential damages. The explosion on the blue phase was vented in all directions and also downwards through the circuit breaker operating mechanism and control cabinet. 317 MW of load was lost on the electrical network as a result of this incident.

Discussion on the possible causes of failure

Defects in the interrupting chamber components

In the case of the circuit breaker at Mill, this is highly likely since the waveforms obtained from the circuit breaker trip test in June 2007 show that when the circuit breaker was opened, the blue phase still showed signs of conducting (see Appendix 1).

There may have been a defect in the blue phase interrupting column of the Luano circuit breaker on account of the numerous incidents of lightning-related trip-outs experienced (44 times since commissioning). One may suggest that the circuit breaker contacts in the blue phase interrupting column did not open, or did not fully open and hence when the abnormal load crossed the line, it made contact with the blue phase conductor thus generating a fault current. The protection relays at Luano operated, meaning the breaker was closed and thus giving the current and voltage signals, through the closed circuit breaker primary contacts, to the CTs and VTs on the line side of the circuit breaker. Therefore, it is thought that the fault current thus generated in the blue phase, with a condition of contacts that are not fully separated, led to arcing, heating and decomposition of the SF6 gas in the circuit breaker blue phase column, leading to high pressure in the column and the eventual explosion.

Mechanism failure

This appears unlikely for the circuit breaker at Mill substation because investigations after the failure revealed that moving contact travel was established and the mechanism and its components were functioning properly.

However, for the circuit breaker at Luano, the explosion originated from the blue phase interrupting column, and spread out to the yellow and red phases. The explosion on the blue phase was also directed downwards, and the blue phase bearing housing was found cracked and operating cranks / levers were found out of position / detached. It has to be ascertained whether this was as a result of the explosion or if there was a mechanical defect.

Loss of SF6 gas insulating properties

In view of the fact that there were numerous trip outs on the line associated with lightning (44 since commissioning), the SF6 gas properties may have been compromised due to SF6 gas decomposition after arcing across the contacts during fault clearing operations. Products of SF6 gas decomposition include hydrogen fluoride, carbon tetra-flouride and hydrolysable fluorides, all of which are corrosive in nature and can lead to loss of insulating properties and arcing across open circuit breaker contacts. These corrosive by-products can also degrade insulating materials that are present in the circuit breaker interrupting columns.

Interaction with the equipment manufacturers of the switchgear

The switchgear manufacturers, Siemens S.p.A of Italy, were contacted after the 1st circuit breaker failure on 2 August 2007. The aim was to have Siemens investigate the failure and ascertain its cause(s) so that remedial measures could be put in place to prevent a recurrence. These efforts did not bear fruit as Siemens offered to replace the damaged circuit breaker pole, at CEC's cost. CEC felt this was not appropriate – what was appropriate was to investigate the cause of the failure. It was only after the second circuit breaker failure of 10 August 2008 that Siemens agreed to send technical experts to investigate the causes of the two failures and test the remaining circuit breakers to determine their reliability for continued use on the electrical network. These tests were to be carried out, at CEC's cost, commencing in October 2008.

Our opinion of the response shown by Siemens is that the investigations and testing of the remaining circuit breakers in service should have been done at Siemens' cost, or the costs could have been shared. We feel this would have been the prudent action for Siemens to take.

Preliminary conclusions

The failure experienced on the circuit breaker at Mill substation is most likely due to a defect in the interrupting chamber, on the insulating separator.

The failure at Luano switching station is thought to be either due to lack of proper moving contact separation in the blue phase (either contact jamming or mechanism failure) or loss of insulating properties of the SF6 gas. These factors, with the fault current caused by the contact of the abnormal load with the blue phase line conductor and resulting high fault current, led to the circuit breaker explosion, originating from the blue phase. The fact that the protection relays operated at Luano lends credence to the thought that the circuit breaker remained in a closed position, probably the blue phase contacts only.

Actions currently being undertaken

- Procure an SF6 gas analyser to determine the condition of SF6 gas in circuit breakers.
- Improve the lightning performance of our transmission lines.
- Engage Siemens in investigating the circuit breaker failures to understand their causes and put forward preventive measures.
- Engage Siemens in testing the remaining circuit breakers that are in service so that their reliability for continued use can be ascertained.

See Apendix 1, 2 and 3 on page 94...

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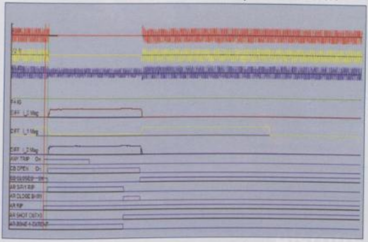
Appendix 1:
Waveform on the mill line circuit breaker after trip test in June 2007.



Appendix 2:
Mill circuit breaker pictures

Damage to blue phase shown on site.

Main Fixed contact on red/yellow phase.

Blue phase breaking cylinder showing the melted and deformed side where tracking and arcing across to the moving contact might have occurred.

Checking the operating mechanism. A straight edge is placed on top of the three contacts to check for any discrepancies. Breaker in open position.

Checking the operating mechanism. A straight edge is placed on top of the three contacts to check for any discrepancies. Breaker in closed position.

Deformation to mechanism housing.

Appendix 3:
Luano circuit breaker pictures

Piece of blue phase fixed arcing contact on the ground.

Failed circuit breaker on site.

Piece showing blue phase fixed and moving contacts stuck together.

Operating shaft with linkages off.

Detached linkage for blue phase column.

"Near-fatal" incident in Germiston area

An event referred to as a "near miss" or a "near fatal incident" occurred. The incident, therefore, requires the same actions as a fatal incident.

by Stephen Delport, Ekurhuleni Metropolitan Municipality

For the purpose of preventing incidents of this nature, the report is shared with all others.

The purpose is to report and inform all on the electrical incident that occurred in Ekurhuleni, Germiston area, corner of Newton and Essex Roads, when three persons of a contracting firm sustained serious burns while performing work on 6600 V cables when at the same time personnel of the Germiston electricity division performed switching operations.

Motivation

On instruction, an investigation team led by the chief engineer: operations, electricity, corporate, investigated the incident.

An almost fatal incident occurred in the Germiston area, corner of Newton and Essex Roads, when three persons from a contracting firm sustained burns while working close to a 6600 V cable when at the same time personnel of the Germiston electricity division performed switching operations.

A further reason for reporting this incident is due to the fact that this incident can be described as an event referred to as a "near miss" or a "near fatal incident". The incident, therefore, requires the same actions as a fatal incident.

Investigation team

- Chief engineer: operations: MI Electricity corporate office
- Chief engineer: maintenance, MI Electricity corporate office
- Area manager: Alberton CCC
- Senior engineer: protection, test and metering: Brakpan CCC

Definitions

Danger: Anything that may cause injury or damage to persons or property.

Hazard: The source of or an exposure to danger.

Risk: The probability that injury or damage will occur.

Safe: Free from any hazard.

At the investigation, the senior engineer: operations and maintenance, Germiston electricity division, explained to the investigation team the detail that led to this incident.

A contractor's worker was burned on both legs just below the knee and left arm and was hospitalised for two days. Another worker was also burned on both legs and both arms and was hospitalised for one day.

Incident particulars

Place/address of incident: cnr. Newton and Essex Roads, Meadowdale, Germiston

Name of person injured: Messrs. X and Y

Position of injured person - contractors

Operational personnel involved: Messrs. A & B & C & D

Statements received: Messrs. A & B & C & D

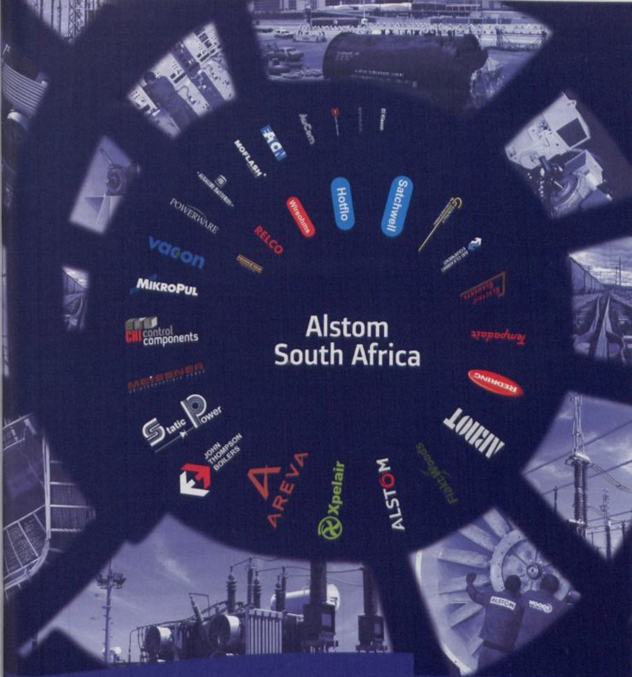
On a Monday morning, at approximately 09h00, A, an electrician, was requested by his senior, B, to investigate a "no power" complaint from a customer receiving his supply from Rietcons 33 kV Substation, panel 59.

On arriving at the substation, A found that panel 59 tripped (in the off position) and that the over-current and master trip relays indicated that a trip had been initiated.

Apparently B then instructed A to reset the indication relays and to make an attempt to close (switch-on) panel 59 circuit breaker. It was then reported by A that panel 59 circuit breaker tripped again.

Following the attempt to switch on panel 59, C reported that people were injured (burnt) at the corner of Newton and Essex Roads, Meadodale, Germiston, where he and a contractor were working close to and around an open joint pit.

Fig. 1: The joint pit.



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On investigating the incident, it was found that on-site cable work had already been performed on the day prior to the incident at the corner of Newton and Essex Roads which contributed to the incident on the day of the incident.

Not all preparation work and some switching operations carried out on the day prior to the incident will be described in detail. The investigating team did not regard all of it as important factors that contributed to the cause of the incident. However, the statements received did describe most of the work performed.

On the day prior to the incident, D apparently identified a specific cable to be worked on in a joint hole among other cables. A certain cable-identifying instrument was used to assist the Germiston personnel to identify the correct cable to be worked on.

After the cable was identified as the "correct" one to be worked on, it was spiked, intentionally damaging the cable to prove that the cable was "off" and to protect personnel from coming into close contact with a possibly live cable.

Apparently, once the cable was safely isolated, earthed and spiked, the personnel incorrectly assumed that they were to perform work on the "correct" required cable and that there was no hazard or danger to prevent the contractor from proceeding with the work.

However, the investigation team is of the opinion that had the involved operational staff performed a basic continuity test on the day prior to the incident, they would have realised that they had identified the incorrect cable to be worked on. Thus after spiking and cutting an incorrect (live) cable or possibly an old redundant cable, a basic continuity test to confirm that the correct cable had been identified should have been performed.

The investigation team is of the opinion that all authorised operational personnel should be aware of such dangers involved in electricity and should as far as practicable follow the following essentials to perform work safely on electrical, equipment, switchgear, transformers, machinery, wires and/or cables.

These essential steps are as follows:

- A visible circuit element must be "switched-off", "tested" and "earthed;"
- A visible "test" "dead" meaning "switched-off;"
- A visible "earth/s" must be installed to protect the circuit from being electrically charged;
- The person spiking the cable shall wear a protective safety flash suit and follow all other operational procedures as stipulated in the operational procedures and policies: section No.10: spiking of cables;
- A continuity test must be carried out that will confirm that the correct cable/overhead line/switchgear/transformer or machinery has been earthed to prevent the equipment from being charged or made live; and
- As far as practicable no person(s) shall be allowed to do work in a joint pit whenever switching operations are to be performed in a specific area, even when that area is perceived not to be affected.
- A work permit is to be issued, by the authorised person, to responsible personnel/contractors performing the task.

Wherever practically 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 (unskilled or semi-skilled) be allowed to start work on applicable electrical equipment/switchgear/transformers/machinery/wires and/or cables.

Such a procedure is deemed necessary as electricians/artisans unfortunately, from time to time, seem to take so-called "short cuts" or implement incorrect work methods used over years. They do not always regard it as necessary to follow the recommended safe operational procedures.

The requirement to "test" whether the correct circuit is "live" (meaning "switched-on") or "dead" (meaning "switched-off") before work is performed cannot be over-emphasised.

Conclusion

The investigating team acknowledges that the specific cable identifying instrument may not be reliable or trustworthy enough to identify a specific cable and that the personnel followed the correct procedure in spiking the identified cable by D.

The investigation team found that no continuity test was performed immediately after spiking the identified cable in order to prove that work could have been performed on the correct cable.

Should the responsible operational officer, B, have performed a continuity test prior to authorising the work to proceed, and not only afterwards, the incident could have been prevented.

It is a matter of concern that no proof that a working permit was issued by the Germiston operational staff could be found. This is a standing instruction. Although, under the circumstances, a working permit would

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probably not have prevented this incident from happening, it is seen as a serious sign that short-cuts are being taken, which may lead to dangerous situations arising.

A statement made by B: "We did a continuity test and realised we had spiked the wrong cable. From the new K4 I could get no continuity on one of the cables. At that stage we checked the substations in the area and saw that the power was on. It looked like we spiked a redundant cable as we were not aware of any power failures". It is clear that the assumption was made that they had probably spiked a redundant cable while in fact they had spiked a live 6600 V cable. This further stresses the point that a confirmed test is required rather than to make any assumptions while working on dangerous high or medium voltage electrical networks.

For the sole purpose of preventing incidents of this nature, it was recommended that the training centre manager in conjunction with the Germiston CCC senior engineer: operations and maintenance, prepare an informative presentation on the incident and that the training manager arrange to share it with all other similar areas' electricity divisions' operational staff to reduce the risk and dangers of similar incidents and injury to employees.

It was also recommended that a record of attendance be kept to ensure that all relevant personnel under their control attend such a presentation/information sharing session.

It is to be mentioned that the OHS Act Electrical Machinery Regulations requirement for work on disconnected electrical machinery regulation 3 states as follows:

"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".

Lastly, but of importance, note is to be taken that the investigation team found that no early alarm warning system was installed at the Rietcons substation in Germiston, and various other substations. This is of real importance. Had the Germiston personnel been informed immediately of a circuit breaker that tripped in the network they would probably have realised that they had spiked the wrong cable.

The following Annexures are attached:

Annexure A: Human Resources: OHS Act section

"The Occupational Health and Safety (OH&S) section supports comments made by the investigation team with the following additions:

- In future the division should have an Occupational Health and Safety (OH&S) officer located in the affected customer care centre (CCC) to be part of the investigation team.
- There was lack of communication between the people who switched on from the one site with the people who were working on the other site.
- Bearing in mind the experience of the municipal infrastructure (MI): electricity personnel who were involved in this accident it indicates that a refresher or induction course is not continuously offered.
- It is not indicated anywhere in the report as to whether a valid contractual agreement between electricity department and Eletassure was entered into.
- No proper personal protective equipment/uniform was used during the course of work.
- There is an indication of unclear safe work procedures and lack of communication on safe work procedures.

Recommendations:

- Involve OH&S officers in the investigation of major accidents (fatal cases).
- Improve the communication system especially between call centres and field workers who perform work from different places, poles, substations etc.
- Provide continuous training, supervision and monitoring of electricity personnel.
- Always enter into a valid contractual agreement with all contractors, and furnish the OH&S section with a copy of the contractual agreement entered into.
- Document and strengthen the communication of safe work procedures.
- Do job analysis of each task and provide appropriate personal protective equipment or clothing."

Recommendation

- That the contents of the report – the electrical incident that occurred at the Germiston CCC, corner of Newton and Essex Roads, when three persons of a contracting firm sustained burns while working close to a 6600 V cable when at the same time personnel of the Germiston electricity division performed switching operations – be noted.
- That authorised electrical operational staff be instructed to as far as practicable, also perform a continuity test from the point of work to prove that the correct cable/ switchgear/overhead line/transformer or machinery is correctly identified. That all precautions be taken by earthing and testing to prevent applicable electrical equipment/switchgear/transformers/ machinery/ wires and/or cables, or adjacent electrical machinery from being charged or made live while persons are working thereon.
- That the following essential steps as far as practicable, be followwed:
  - A visible circuit element must be "switched-off", "tested" and "earthed"
  - A visible "test" for "dead" (meaning "switched-off") must be performed
  - A visible "earth/s" is to be installed to protect the circuit from being electrically charged.
  - The person spiking the cable shall wear a protective safety flash suit and follow all other operational procedures as stipulated in the operational procedures and policies: section No.10: spiking of cables.
  - As far as practicable, a continuity test be carried out that will confirm that the correct cable/overhead line/ switchgear/transformer or machinery has been earthed to prevent the danger of being charged or made live.
  - As far as practicable, a visible continuity test be carried out that will confirm that the correct cable/ overhead line/switchgear/transformer or machinery has been earthed to prevent the danger of being charged or made live.
  - As far as practicable no person(s) be allowed to do work in a joint pit whenever switching operations are to be performed in a specific area, even when that area is perceived not to be affected.
  - Work permit to be issued, by the authorised person, to responsible personnel/contractor performing the task.
- That the essential steps above be approved and be adopted and included in the electricity and energy department's standing instructions.
- That for the sole purpose of preventing incidents of this nature, the training centre manager in conjunction with the Germiston CCC senior engineer: operations and maintenance, prepare an informative presentation on the incident and that the training manager arrange to share it with all other CCC's electricity divisions applicable operational staff members to reduce the risk and danger of injury to employees.

Substation fatality

An adult male was fatally injured in an 11 kV distribution substation while cleaning inside an oil-filled circuit breaker (OCB) chamber of the vertical isolation, horizontal draw-out type. In the process of cleaning, he opened the cable shutters in order to clean the inside of the spouts and was electrocuted.

by Barry Gass, Alstom Protection & Control

Sequence of events

The electrical planning department advised the HT maintenance division that the 11 kV OCBs in a local substation were due for a service and oil change.

The acting supervisor decided that this particular substation could not be switched off during normal working hours and it would be necessary for the job to be done on Sunday night so that the local textile industry would not be affected by a power interruption.

It was assumed that the local textile factories were fed from the local substation but the acting supervisor (authorised person) did not check where all the circuits were fed from.

On Sunday night the HT maintenance crew arrived at the substation to carry out their task of maintaining the circuit breakers and changing the insulating oil.

The team set up their generators so that the necessary power would be available when the substation was isolated.

One of the OCBs was open on arrival, so the crew serviced the breaker and changed the oil in the OCB tank.

The necessary procedure was carried out in order to isolate the 11 kV supply to the substation.

On isolating the supply to the substation and isolating the local transformer, it was found that the textile factories still had power, and in fact were not fed from this particular substation.

The local transformer only fed street lighting circuits.

The maintenance and oil changing in the remaining OCBs was completed and the assistants were instructed to clean the substation.

One of the assistants went into the substation to clean the floor, panels and spouts as he had been instructed; he had been told that the substation had been isolated.

In the process of cleaning the chamber he opened the cable shutters and attempted to clean inside the spout, which was alive because it was fed from a closed ring, and was fatally injured.

At the time of the incident all the supervisors and artisans were outside the substation.

Contravention

The acting supervisor failed to obey the standing safety instruction in that:

On the removal of an OCB from the chamber all live shutters (potentially live) must be locked off with a personal lock and a "Danger - do not make alive" label applied.

The supervisor had been trained in the process of HT switching and the necessity of locking the shutters in the interest of safety.

The supervisor had signed acceptance of the HT safety instructions.

The supervisor had been provided with the necessary personal locks to lock the shutters once the OCB had been removed from the chamber.

On isolating the substation he failed to test to ensure that the substation was, in fact, dead.

The supervisor had the necessary means to test that the substation was in fact isolated from all possible sources of supply.

In this instance the outgoing cable of the open OCB in the substation was in fact alive and was being back-fed from another substation.

Cause of the incident

The supervisor failed to obey the HT safety instructions and failed to use safety equipment provided to him by the employer.

Conclusions

- The planning of the maintenance and oil change was poor.
- The motive was to work Sunday overtime.
- The local transformer only fed street lighting.
- There was a lack of proper supervision.
- The supervisor (authorised person) failed to lock off the cable and busbar shutters in terms of the HT safety instructions.
- The supervisor (authorised person) failed to test that the substation was in fact isolated.

Contraventions

No contraventions on the part of the employer were found in that the employees were trained in the company safety instructions and use of HT equipment and were familiar with the equipment.

- *OHSA 1993 Section 14(c):* The employee-supervisor failed to carry out a lawful order and disobeyed the safety rules and procedures laid down by the employer.
- *OHSA 1993 Section 14(a):* The supervisor failed to take care of the assistants who were directly affected by his omission, i.e. to lock the shutters once the OCB had been withdrawn.
- *OHSA 1993 Section 38(a):* The supervisor failed to use the safety equipment in connection with plant or machinery, which was provided to him by the employer.
- Alternatively, he is guilty of culpable homicide – SAPS.

Court case results

Both the supervisor (authorised person) and the competent person assisting the authorised person were found guilty of culpable homicide and fined.

Correct operating procedure

When operating on medium and/or high voltage switchgear and/or apparatus it is imperative to follow company safety rules and operating regulations in order to comply with the OHSA 1993.

To make electrical equipment safe to work on an operator should follow the ISITE acronym:

- *Identify:* correct substation; correct operating device.
- *Switch:* the opening or closing of electrical mains and/or apparatus
- *Isolate:* physically disconnect apparatus from all possible sources of electrical potential
- *Test:* safety test
- *Earth:* connect to the general mass of earth in such a manner so as to ensure at all times an immediate safe discharge of electricity takes place.
- *ISITE:* issue work permit – written authorisation for work to be carried out on electrical mains or apparatus.

Identify

The authorised person should ensure that he is at the correct operating location and the correct isolation/earthing device.

Switching

This should be carried out where possible, and can be done using a remote control switch, hard wire remote device, electronic remote device, or by using the time delay operating feature on some relays.

Isolating

This can be achieved by racking out the circuit breaker and locking off ALL live shutters with a personal lock and applying a danger label. Some circuit breakers have an isolating position that they can be locked into within the panel, preventing access to the shutters.

Testing

This should be carried out using an approved 'live' voltage detector. This voltage detector must be an 'S' type tester for use on switchgear and not an 'L' type voltage detector for use on overhead lines only. A proximity tester should only be used on overhead lines.

Earthing

The method of earthing switchgear is dependent on the type of circuit breaker.

This can be done by either:

- Integral earthing: earthing equipment fitted to the circuit breaker and/or panel in order to earth the circuit.
- Using external attachments: attachments designed by the manufacturer to be fitted to the circuit breaker in order to earth the circuit.
- Using an earthing truck: an earthing truck designed by the manufacturer to be used to earth the circuit. Earthing trucks are usually painted red and only have one set of stems for entry into the respective spouts to be earthed.

It is also possible to earth the busbars, but it must be remembered that all circuit breakers that are racked into the busbar must be opened, isolated, and both sets of shutters locked off with a personal lock and a danger label and the busbar must be tested before applying an earth.

MV/HV operating can only be carried out by an authorised person. This is a person authorised in writing by the electrical engineer or his nominee to carry out switching, isolating, testing and earthing procedures on electrical mains and/or apparatus in liaison with, and under the instruction of, the control officer, to issue work permits, and to operate within the limits and restrictions of his authorisation as listed on his authorisation certificate.

Personal protective equipment

This is dependent on the specific hazards within the particular industry, but the employer must supply adequate protective clothing to protect the employee against the hazard - normal overalls, flame retardant overalls or a flash suit.

It should be noted that the employer should as far as is reasonably practicable, remove the hazard before resorting to personal protective equipment (PPE).

The authorised person should be accompanied by a competent person when earthing and issuing a work permit.

Planning the job

The job was not planned properly, and circuit diagrams were not consulted in order to ascertain all possible sources of supply. It was assumed that the substation would be isolated if the incoming circuit was isolated.

Remember: "Proper preparation and planning prevents poor performance." Never assume anything!

Safety testing was not carried out using an approved live 'S' type voltage detector as required by the regulations, and the competent person assisting the authorised person did not ensure that this was carried out according to his duties.

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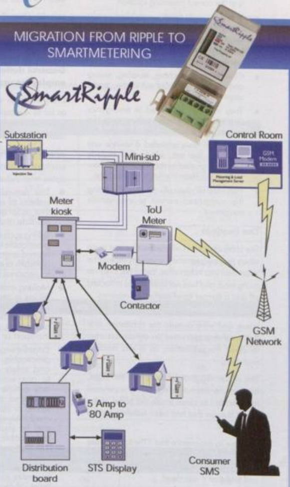

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Duties of competent persons observing testing and earthing of mains and apparatus:

- They must be conversant with the service unit safety rules.
- They must verify that the authorised person is at the correct operating location.
- They must verify that the authorised person is at the correct isolation/earthing device.
- They must be conversant with the switching, isolating, testing and earthing principles relevant to the mains and apparatus.
- Observe that switching, isolating, testing and earthing is carried out in the correct sequence.
- They must be instructed in emergency procedures including the safe removal of a person from live mains and apparatus.
- They must have attended a service unit course in first aid, which shall include treatment of electric shock, CPR and how to deal with heart fibrillation or stoppage.
- They must be physically capable of assisting the authorised person to manhandle equipment.

The incident

The cable on the circuit breaker that was open when the maintenance crew arrived at the substation was in fact alive, being back fed via a ring feed, and had not been tested or locked off and a danger label applied as required.

During the maintenance the workers took a break and were outside the substation and the supervisor instructed an artisan assistant to clean the substation, as it was isolated and dead.

The artisan assistant did as he was instructed, however, he was not being directly supervised and decided to clean inside the panel of the circuit breaker that had been withdrawn to be maintained.

He knew by experience that if the spouts were alive the shutters would be locked off, and in addition he had been instructed to do the job, and told that it was dead.

The artisan assistant then opened the cable shutters and holding a cloth, put his hand inside a live spout and was electrocuted.

On investigation it was clear that the company rules and regulations were not followed and as this was a reportable incident, a Department of Labour enquiry was held.

Questions asked by the Department of Labour at the enquiry

- Were there rules and regulations in place for the task involved?
- Were the people trained?
- Do you have a record of their training?
- When were they last trained?
- Was the training relevant?
- What tests were carried out in order to assess competency?

The designated person (person holding the Government Certificate of Competency) produced training records of both the authorised and competent persons, which satisfied the Department of Labour that the designated person and the company had carried out his/their duties in terms of the OHSA 1993 and were not liable for prosecution.

However the authorised person and competent person were found to have contravened the OHSA 1993 and company's rules and regulations.

General duties of employers to their employees under OHSA Section 8

Every employer shall provide and maintain as far as is reasonably practicable, a working environment that is safe and without risk to the health of his employees.

Without derogating from the generality of an employer's duties, the matters to which those duties refer include in particular:

- The provision and maintenance of systems of work, plant and machinery that, as far as is reasonably practicable, are safe and without risks to health;
- Taking such steps as may be reasonably practicable to eliminate or mitigate any hazard or potential hazard to the safety or health of employees, before resorting to personal protective equipment;
- Making arrangements for ensuring, as far as is reasonably practicable, the safety and absence of risks to health in connection with the production, processing, use, handling, storage or transport or articles or substances;
- Establishing as far as is reasonably practicable, what hazards to the health and safety of persons are attached to any work which is performed, any article or substance which is produced, processed, used, handled, stored or transported and any plant or machinery which is used in his business, and he shall as far as is reasonably practicable, further establish what precautionary measures should be taken with respect to such work, article, substance, plant or machinery in order to protect the health and safety of persons, and he shall provide the necessary means to apply such precautionary measures;
- Providing such information, instruction, training and supervision, as may be necessary to ensure, as far as is reasonably practicable, the health and safety at work of his employees;
- As far as is reasonably practicable, not permitting any employee to do any work or to produce, process, use, handle, store or transport any article or substance or to operate any plant or machinery, unless the precautionary measures contemplated in paragraphs (b) and (d) or any other precautionary measures which may be prescribed, have been taken;
- Taking all necessary measures to ensure that the requirements of this Act are complied with by every person in his employment or on premises under his control where plant or machinery is used;
- Enforcing such measures as may be necessary in the interests of health and safety;
- Ensuring that work is performed and that plant or machinery is used under the general supervision of a person trained to understand the hazards associated with it, and who have the authority to ensure that precautionary measures taken by the employer are implemented;
- Causing all employees to be informed regarding the scope of their authority as contemplated in section 37 (1) (b)

General duties of employees at work — OHSA section 14

Every employee at work shall:

- Take reasonable care of the health and safety of himself and of other persons who may be affected by his acts or omissions.
- As regards any duty or requirement imposed on his employer or any other person by this act, co-operate with such employer or person to enable that duty or requirement to be performed or complied with;
- Carry out any lawful order given to him, and obey the health and safety rules and procedures laid down by his employer, in the interests of health and safety.
- If any situation which is unsafe or unhealthy comes to his attention, as soon as practicable, report such situation to his employer or to the health and safety representative for his workplace or section thereof, as the case may be, who shall report it to the employer;
- If he is involved in any incident which may affect his health or which has caused an injury to himself, report such incident to his employer, or to his health and safety representative as soon as practicable, but not later than the end of the particular shift during which this incident occurred, unless the circumstances were such that the reporting of the incident was not possible, in which case he shall report the incident as soon as practicable thereafter.

Conclusion

The onus was on the designated person to prove to the Department of Labour by producing records that there were rules and regulations in place for the task involved and that the acting supervisor who was the authorised person and the competent person were both trained and assessed.

It is therefore important that all staff members are trained and assessed by a registered assessor and proper training records kept, in order to protect the company and the designated person.

It is interesting to note that both the authorised person and the competent person were found guilty of culpable homicide and fined the same amount, as they both failed in their duties in terms of the safety rules and regulations.

They were deemed by the judge to be equally responsible. It is evident from the above that the competent person assisting the authorised person when observing testing and earthing of mains and apparatus must conform to the requirements listed above and an untrained person cannot be used for this purpose.

Revenue protection in Emnambithi/Ladysmith municipality – let's start with a meter sweep

Emnambithi/Ladysmith Municipality, like most municipalities, is faced with the growing problem of non-technical losses. It is difficult enough in the current electricity climate to manage a small-scale utility and having the additional problem of electricity theft is certainly unwelcome. This paper discusses Emnambithi/Ladysmith Municipality's approach to dealing with this growing problem. The paper will deal mostly with the development of a structured process of meter sweeping as well as the implementation of further control measures to minimise future losses.

by F R Niemand, Emnambithi/Ladysmith Municipality

Emnambithi/Ladysmith municipality, although a relatively small utility, is the sixth biggest municipal electricity distributor in Kwazulu-Natal. The municipality includes the townships of Ladysmith, Steadville and Colenso. Electricity is purchased from Eskom at 132 kV in Ladysmith and 6,6 kV in Colenso. The municipality has 14 061 electricity customers with an annual turnover from electricity sales of approximately R87-million (2007/2008). A breakdown of the customers and the respective income from each customer group is shown in Table 1.

Customer category	Customer	Energy/kWh	Income (Incl VAT)
Temporary supply	22	162 627	R2 051 728
Residential - credit	6084	68 163,504	R25 848 392
Commercial	1142	30 903 403	R17 159 545
Prepaid - indigent	2500	4 500 000	R1 339 000
Prepaid - domestic	4200	17 136 000	R7 651 224
Prepaid - commercial	30	720 000	R388 800
Industrial - LT	52	16 603 623	R7 181 453
Industrial - HT	31	91 083 534	R25 173 868
Total	**14061**	**229 272 691**	**R86 794 011**

Table 1: Customer classification and 2007/2008 Income.

Loss calculations

The annual losses (both technical and nontechnical) are detailed in Table 2. Losses amount to approximately 15% of the total electricity purchased from Eskom. If one considers a 6% technical loss (assumed and includes streetlight losses of approximately 1 GWh per annum) then theft accounts for a 9% loss. The direct cost to the municipality is approximately R4,264-million per annum with a loss of income to the municipality of approximately R10-million.

Category	kWh	Percent
Electricity purchased	268 215 312	100%
Electricity sales	229 272 691	85%
Losses	38 942 621	15%
Technical (assumed)	16 092 919	6%
Theft	22 849 703	9%
Cost at R0,1866	R4 263 755	
Income Lost at R0,44	R10 053 869	

Table 2: Loss calculation.

Distribution of losses

The paragraph above shows theft to be approximately 9%. It is however interesting to take a more detailed look at this figure as it may be misleading. Table 1 shows that approximately 47% of the total energy sales are to industrial customers. Due to the small number of industrial customers and their regular inspection (monthly) one can assume that few losses occur here. It therefore implies that losses are actually in the order of approximately 17% if one eliminates the sales to industrial customers. Stretching this point even further by apportioning say 50% of the losses to credit meter customers (both residentiel and commercial) implies that the losses from prepaid customers could be as high as 51% based on units sold. See Table 3.

Customer category	Sales	Loss distribution	Loss amount	Percent
Temporary	162 627	0%	0	0%
Residential - Credit	68 163 504	25%	5 712 426	8%
Commercial	30 903 403	25%	5 712 426	18%
Prepaid	22 356 000	50%	11 424 852	51%
Industrial	107 687 157	0%	0	0%
Total	**229 272 691**	**100%**	**22 849 703**	**10%**

Table 3: Distribution of losses.

It is clear from the above analysis that Emnambithi/Ladysmith municipality has a major problem with losses especially in respect of prepaid meters. A meter sweep is therefore clearly required to eliminate these losses.

Meter sweep

Aim

The major aim of the meter sweep will be to minimise the loss of revenue from meter tampering. There is however a secondary aim which is just as important. This revolves around the data clean up. As with most electricity utilities in South Africa, the Emnambithi/Ladysmith municipality customer database is not that reliable. This clean up essentially aims to:

- Ensure all electricity connections are accurately recorded in the customer database.
- Verify and record the electrical address for each meter for future loss monitoring.

Outsource or in-house

A decision whether to outsource the meter

sweep to an external service provider or undertake the project in-house had to be made. The previous meter sweep, undertaken in 2004, was outsourced. While the results were most certainly satisfactory, the professionalism of the service provider was brought into question. Furthermore, it is pertinent to note that the main labour force used in a meter sweep is semi-skilled. These persons can be readily sourced within local communities and this fits with the municipality's job creation programme.

Due to previous experiences with outsourcing and the fact the municipality had the necessary expertise internally it was decided to undertake the meter sweep in-house. It is however noted that service removals will still be outsourced due to the municipality's shortage of electricians.

Basic process

As defined in the meter sweep aims, it is critical that the meter sweep strengthens the customer database specifically to ensure all meters are registered and have an electrical address. Since the municipality operates a lot-based management system, the meter sweep is also done using lots as the chief control measure.

Customer awareness/education

Customer awareness and education is critical. It is the opinion of the author that this is the biggest problem facing the revenue protection practitioner. There is major denial as to the level and impact of this problem. We have created the euphemism "non-technical losses" to describe theft. The CEO of Eskom, Jacob Maroga, describes the theft of electricity as "very low" and politicians skirt the topic as if it were the plague. Utility engineers are scared to act, as they fear their political masters.

In Ladysmith, an extensive awareness campaign was done through local media, ward committees and distribution of pamphlets within the community. This however still proved to be insufficient as once the disconnections started in earnest, amnesia set in.

Staff integrity

In-house staff are just as prone to bribery as any other person. The temptation is massive and this must be considered when developing the meter sweep process. Since it is noted that bribery of sweep inspectors is likely to occur, systems must be put in place to cater for this potential dilemma. Let us consider how a sweep inspector can falsify records in order to receive a bribe and how this can be combatted.

Vacant land

Report the stand as being vacant land and hence no meter exists. This can be verified by checking the valuation roll to ensure that the stand is in fact vacant.

No supply/supply removed

Report stand as having either no supply or the supply has been removed. This will be checked against information available but ultimately require a follow up visit.

All okay

The inspector reports the meter as all okay. In this instance the customer's purchasing (in the case of prepaid meters) or consumption (in the case of credit meters) must be checked. Any potential problem must be flagged as either;

- Query – revisit is required.
- Potential tamper – installation is to be monitored.

Damaged/faulty

The meter inspector reports the meter as damaged or faulty. In these instances, the meter will be re-inspected by the electrician dispatched to do the meter replacement.

No inspection sheet completed

The inspector fails to complete an inspection sheet at all. This will be detected by GIS verification.

Cadastral information

Emnambithi/Ladysmith municipality has very few customers (approximately 100) that do not live in formal housing. For this reason meter sweeps are based on the latest cadastral information available. Every inspection must be linked to an erf number.

Electrical infrastructure – electronic data

The bulk of the electrical infrastructure in Emnambithi/Ladysmith municipality has not been captured onto a GIS system. For this reason, the first phase of the sweep process is to add transformers and LV circuits to the GIS database.

Transformer/circuit control

Sweeping will be done by transformer and LV circuit. Essentially meter inspectors are provided with a drawing showing the transformer location and LV circuit layout along with the cadastral information. They are then to sweep properties fed from the LV circuit.

Status	Initial Status		Current Status	
	Quantity	Percent	Quantity	Percent
Complete	2509	66,8%	2534	67,4%
Customer to call	496	23,2%	28	0,7%
Hard disconnect done	0	0,0%	57	1,5%
Hard disconnect pending	205	5,5%	302	8,0%
Meter change pending	60	1,6%	59	1,6%
Query	333	8,9%	329	8,8%
Query - meter error	124	3,3%	124	3,3%
Revisit pending	28	0,7%	28	0,7%
Soft disconnect pending	2	0,1%	296	7,9%
Total	**3757**	**100,0%**	**3757**	**100,0%**

Table 4: Meter inspection status migration

Status	Initial status		Current status	
	Quantity	Percent	Quantity	Percent
Complete	954	74,01%	1026	97,99%
Hard disconnect done	49	3,80%	1	0,10%
Hard disconnect pending	112	8,69%	8	0,76%
Meter change pending	27	2,09%	2	0,19%
Query	130	10,09%	5	0,48%
Revisit pending	16	1,24%	3	0,29%
Soft disconnect pending	1	0,8%	2	0,19%
Total	**1289**	**100,0%**	**1047**	**100,0%**
Temper	161	12,49%	9	0,86%
Potential temper	147	11,40%	10	0,96%
Total	**308**	**23,89%**	**19**	**1,81%**

Table 5: Meter inspection status by meter type.

Fig. 1: Transformer status diagram.

Data capture

Using an internally developed management system, data capture is done in a structured and controlled manner. This management system only allows data to be entered in a specified manner. It furthermore ensures that all the necessary checks and balances are put in place.

No access

Inability to gain access to inspect the meter is a major problem. In many instances, residents see the inspectors coming and they lock their houses. The sweep policy is to leave a notice requesting that the consumer contact the municipality to arrange an inspection. If they fail to respond the service will be terminated.

Sealing

Part of the sweep process is to reseal all meters.

Job cards

The meter sweep process generates numerous job cards that need to be controlled from inception to completion. Job cards generated include:

Hard disconnect – tamper

Meter was found tampered so hard disconnect is to be done.

Meter change (damaged/faulty)

Meter was found to be faulty or damaged and must therefore be replaced.

Revisit – query

There is a potential problem with the inspection and therefore it needs to be reinspected by a senior official.

Soft disconnect – no access

No access was possible when the inspector visited. The customer has not called to schedule an inspection and 14 days has elapsed so the service will be terminated.

Soft disconnect – refused access

The customer refused access when the inspector visited hence the service will be terminated.

Hard disconnect – no response to soft

If a soft disconnection has been done due to failure to inspect and the customer still fails to respond then a hard disconnection is scheduled after 14 days.

Management system

In order to ensure a successful meter sweep the municipality required an effective electronic management system to manage the project. Since this sort of software is not readily available commercially, it was developed in-house. This system provides all the necessary control defined above. Additional reporting is provided to ensure up to date management information is available for continued supervision.

Staff can, at the press of a button, retrieve reports on inspection progress, area progress, job cards outstanding, daily productivity (both inspectors and data capture clerks), job cards completed etc.

Results

Some of the results achieved to date are detailed here:

Inspection status

Every inspection has an assigned status. As an inspection flows through the system it will go from its initial status to ultimately complete or hard disconnect done. Table 4 shows the current status.

What is pertinent to note is that there is very little increase in the number of inspections completed. This is concerning. It is largely attributed to the fact that there are numerous disconnections outstanding. The current staff shortages have made it impossible to undertake this work in-house. An attempt to source an external service provider to undertake this work failed at first. When a private contractor was eventually found a major backlog had developed.

Furthermore, while tampering is only shown to be 9,5%, if one considers the number of soft disconnections outstanding due to no access, the total potential tamper rate is 17,4%. Add a further 8,8% for queries and the numbers start to get frightening.

Table 5 shows some additional information in respect of the tampering detected. This analysis shows the statistics based on the meter type.

The statistics show a tamper rate of 12,49% for prepaid meters plus an additional 11,40% for potential tampers making the tamper rate on prepaid meters approximately 23,89%. A similar analysis on credit meters shows a tamper rate of 1, 81%. It should be further noted that there are 296 soft disconnections pending (Table 4) of which the majority are in prepaid areas. If we assume 200 of these are in fact prepaid meters and 80% are tampered hence the reluctance of customers to call this means an additional 160 prepaid meters are tampered. This would now mean prepaid tampering is close to 31%.

Transformer status

Tracking inspections by transformer zone is critical. The tool used here is GIS-based giving the supervisors a simple graphical view of the status of a selected transformer. Fig. 1 shows the status of transformer E390, LV Circuit 3. Issues highlighted here are:

- Erf 1609 has the incorrect electrical address
- Erf 1459 and 1631 have no inspection record.

Targeted sweeps

The principle of meter sweeps and the need thereof is well documented. The cost of undertaking these sweeps must however be considered. Emnambithi/Ladysmith municipality intend to implement a policy of targetted sweeps. The issue is however; where to target? In this regard check metering will be installed throughout the municipality. This metering will monitor either individual or groups of transformers as transformer zones (approximately 200 customers). The total energy dispensed into these zones will then be compared to the energy consumed by the meters connected within that zone. As soon as the losses start to rise the transformer zone will be targetted. Results from this principle will be reported when available.

Challenges

There are some challenges facing the municipality. These specifically include:

Supply chain

The supply chain management policy as required by national treasury has caused many delays in the project. As the project gains momentum, this has become less prevalent.

Resources

Probably the biggest single challenge. Emnambithi/Ladysmith has a shortage of electricians. An attempt to outsource disconnections originally proved fruitless – no companies responded to the tender invitation. A private company was eventually found to undertake disconnections.

Legal issues

The Emnambithi/Ladysmith municipality was challenged in court over the legality of removing an electricity meter without a court order. The court ruled that the electricity meter was effectively the property of the house owner and therefore the municipality needed a court order to remove it. The department was ordered to restore the original meter and supply even though the engineer argued that it was a hazardous situation. A court order was subsequently sought and the meter removed. While the disconnection was ultimately carried out the local rate payers association used this as a tool to drum up support against the council.

Conclusion

Electricity losses have a damaging effect on municipalities' viability and, considering the generation constraints facing South Africa, a major impact on our economy. The need to sweep electricity meters, specifically prepaid meters, is paramount.

Political support is also very important. Politicians should stop paying lip service to this problem and tackle it head on. Customer education must be tackled at all levels and must be driven by the political leaders.

Any meter sweep must be well planned and carried out. Comprehensive management software is needed. Such software should integrate with current management systems used specifically GIS, prepaid vending systems and credit meter management systems.

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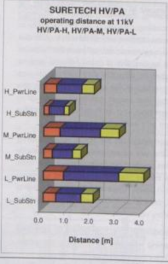

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Curbing non-technical electricity losses in a domestic prepayment environment

This paper proposes a solution to a worldwide tendency, that of increasing non-technical electricity losses, especially amongst residential customers. The primary objective is to prove beyond any doubt that electricity was consumed, doing so with factual evidence, without identifying the manner in which tampering took place, with no photos, no videos or guilty parties and no testifying as to the identity of the actual transgressor or instigator, and finally, to have the proven right to render an account for that consumption.

by D E Cloete, City of uMhlathuze (Richards Bay/Empangeni)

Throughout the electrical industry, ways and means have been established to curb non-technical losses, to substantiate and prove beyond any reasonable doubt, if taken to court, an assertion that electricity has been consumed without payment (in laymen's terms, stolen) and in accordance with promulgated bylaws, to charge the individual transgressor, in this case the owner/tenant with whom the utility has a signed agreement, a transgression fee and an amount in respect of electricity consumed over the period in question.

The dilemma

Prepayment meter technology, which requires a customer to purchase electricity before consuming it, was thought to be a solution for all utilities selling electricity to a residential consumer base as it required no deposits, obviated the necessity for monthly meter readings and gave each customer the facility to manage the purchase of electricity according to personal financial means. This should have been the ultimate revenue solution to a serious financial problem. Credit metered customers effectively consumed electricity and paid for it a month-and-a-half to two months after the last reading, depending partly on efficiency of processing and partly on the necessity to render an account well in advance of its due date. If a customer did not have the financial means to pay, the account fell into arrears and after 14 days the electricity supply was disconnected. If the situation persisted, the customer was served with legal papers or in the worst case, was declared indigent and the amount was written off.

The non-technical electricity losses arising from the act of tampering with electricity supplies, such as bypassing meters, and from illegal connections, have reached alarming levels in South Africa and worldwide. During 2003, over R1,5-billion was recorded as the monetary value lost.

The traditional practice aimed at detecting tampering with electricity supply comprises one or a combination of the following:

- Conducting physical audits at all connection points to search for illegal connections or wiring that bypasses meters.
- Auditing and testing electricity meters and metering installations to detect bridging-out of meters and current transformers or to detect isolation of phase voltages.
- Relying on informants to "blow the whistle" regarding intermittent tampering, which is otherwise extremely difficult to detect.
- Using abnormal variation in purchase patterns as reported by prepayment meter vending software programs that compare statistics of monthly purchase patterns by customer with pre-set average levels (minimum and maximum), highlighting an abnormal variation in the purchase pattern as a "suspected tamper".

All the above approaches are very expensive, require specialised technical skills, are of a temporary nature and enjoy limited success, as in most cases, the physical evidence is removed, thus leaving assumptions and little evidence as proof. Customers who resort to tampering are increasingly becoming more and more entrepreneurial and innovative in their quest to achieve success without being detected, and some even pay for "specialised services", be it as bribes to officials or to third parties.

The deviation of the purchase patterns between the minimum and maximum parameters lends itself to assisting the conscientious "buyer" to purchase just enough not to be detected, in other words, leaving no proof that a proportion of the consumption, perhaps as much as 60%, is not paid for. At the same time, erratic but valid purchases might easily lead to erroneous suspicion of tampering.

The solution: check meter principle

Conventional credit meters, registering normal electricity consumption or base-mounted prepayment meters, which allow prepaid electricity to be consumed, will always create an environment conducive to tampering, as they are single meters installed inline with the main electricity supplying households.

It is in the combination of the two that evidence may be found to aid in curbing non-technical losses. The conventional credit meter is installed outside the property on the road reserve inside a secure metering cubicle / kiosk and inline with the base-mounted prepayment meter situated in the house in close proximity to the main electricity distribution board. Alternatively, a split prepayment, meter and keypad are installed somewhere outside the house and in the house, respectively.

The total consumption of electricity as registered by the credit meter must equal that registered by the prepayment meter over the same period. The credit meter is read periodically (on a three-monthly basis) at a minimal cost. These readings are processed and the consumption compared to that recorded by the prepayment meter. The accepted deviation or discrepancy between the two manufactured meters can only be the combined effect of their individual accuracy class types. Since these meters are of class 2 type, representing 2% accuracy for each, the combined accuracy can only be deemed to be 4%.

Revenue protection: administration

Given periodic readings for every service, the bulk of the auditing (75% to 90%) is done electronically in the office and the remainder by way of physical visits to selected properties to confirm relevant technical detail by recording it on audit sheets/forms. Information available allows a property to be scrutinised by an official with minimum effort, but with excellent results.

Monitoring of properties is an ongoing process and allows hundreds to be processed in a relatively short space of time. Capturing of relevant information is crucial and must be kept up to date. The system is designed to police itself. Every 24 hours:

- Any available new readings are captured
- Purchases as well as consumer and new service data are imported from the vending system by a facility provided for the purpose
- Discrepancy lists are revised

Any property identified in this manner, initiates a physical audit / investigation.

There is no need to audit every household and thereby frustrate the law-abiding citizen, who is paying for his services. This induces a

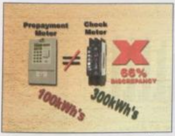

Fig. 1: Proven: tampered property identified.

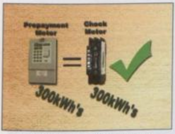

Fig. 2: Proven: consumption confirmed.

positive attitude on the part of the customer towards the council.

Fig. 1 and 2 illustrate the essence of the principle.

It is apparent that customers, whose electricity supplies are identified as having been subject to tampering, will forthwith remove all illegal wiring and or other evidence.

A customer's efforts to present as the innocent "victim", will bring forth all manner of objection, explanation and inconceivable delay tactics, for example:

- No knowledge of electricity, therefore unable to tamper
- Request investigation and proof of how it was done
- Both meters are inaccurate and to be tested
- Neighbours tapped from the supply
- If physical evidence is found, previous owner or tenant was responsible
- Bridging off of electricity supplies to outbuildings, prior to installation of prepayment meter.
- Utility contractors involvement
- Utility officials involved – bribery or own "initiative" of creating additional income
- The check meter principle was not advertised or made known so amnesty must be applied
- An unfair practice – utility out to make money
- Deceased person accountable as per the signed agreement, not the current family members
- No purchases were made for months because meter was faulty and this was reported – no evidence to be found of such report.

On the other hand, investigations reveal various techniques aimed at effecting and/or concealing the tampering, for example:

- Bridging off of electricity supplies to outbuildings, prior to installation of prepayment meter.
- Utility contractors were involved
- Utility officials were involved – bribed or used own "initiative" to supplement inadequate income.

The list is endless, however, to substantiate findings and prove that tampering indeed took place. Purchase history (or consumption) relating to the prepayment meter and consumption registered by the check meter are combined in a graphical representation in Fig. 3.

Historical evidence verifies tamper removal in Fig. 4.

This illustrates that the customer has corrected the delinquent behaviour and become part of the paying customer base once more.

Evidence as depicted confirms that the message will not go unnoticed: "Tampering will be identified!"

With the check meter principle as the solution to an ongoing revenue loss problem, where does one start looking into one's own environment?

Install bulk electricity meters at all the bulk intake supply points in all the different areas under your jurisdiction. Should one take monthly meter readings and compare the bulk meter consumption (energy – MWh's) to prepayment meter purchases (and credit consumption, if any) for the same area, it will become evident which areas suffer the most serious losses and will be possible to concentrate initial application of the aforementioned principle on the identified areas.

Individual check meters are installed or old credit meters retained as check meters, wherever prepayment meters are or have been installed. When new electricity supply connections are made, customers pay for prepayment meters and the utility installs check meters at own cost. This is a process with long-term results. One cannot expect to achieve results within a short space of time. It requires customers to make a paradigm shift from non-paying customers to paying customers.

The essence of this project was to instil in the community a sense of ownership that goes along with the responsibility to pay for services rendered. Those who do not adhere to the above have to face the consequences.

Historical audit sweeps

Unfortunately, this is still generally the only manner in which audits are conducted. Sadly, the effort is usually very expensive and the outcome is the following: the "bush telegraph" is present and cannot be ignored. As the sweep is initiated, a simultaneous message "transcends" the sweep into the identified area, houses are locked, customers "disappear", some hide within and no entry is gained to a large proportion of the premises.

During a sweep of a 1000 households the following was experienced: (see Fig. 5)

Proof that the principle is sound and effective

The City of uMhlathuze identified an area in the year 2000 and action plans were initiated to curb losses in this specific area, which losses were close to 30% during the late 1990s. Audits commenced in extreme earnest in 1999, but positive benefit followed the introduction of the check meter principle:

- Contractors were appointed to read all the existing credit meters (old billing meters) on a three-monthly basis.

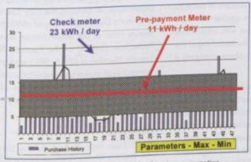

Fig. 3: Purchase pattern versus check meter consumption.

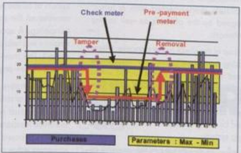

Fig. 4: Removal of tamper (illegal wiring).

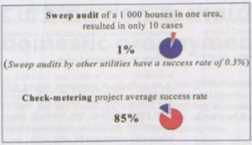

Fig. 5: Sweep versus check meter results.

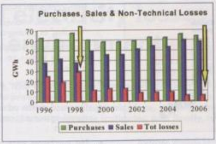

Fig. 6: Purchases, sales and non-technical losses.

Fig. 7: Seals.

- Areas were identified and check meters were installed inline with prepayment meters. This is now standard practice.
- Financial implications are in the order of R395 per conventional meter, including installation costs.
- New software was developed to produce thorough checks and balances between all the relevant data captured from the audit sheets, in order to summarise said information by producing a list of discrepancies identifying "tamper" properties.

The above measures were successfully implemented and the results were excellent. To date over 4500 properties have been identified, an amount of over R10-million has been charged and R8,5-million has been recouped. The return on the capital investment for this project, can clearly be seen by these figures.

The graph (Fig. 6) confirms the results between purchases, sales and electricity losses.

It is essential that all processes be adhered to strictly, for if the occupier of any identified property contests the results, the proof must stand up to close scrutiny. Legal action requires documentation and the results or their proof will be contested in a court of law.

Currently as per the Electricity Act, electricity supply authorities are only allowed to disconnect an electricity supply to a property due to:

- Non-payment of a rendered account after 14 days.
- A publicly unsafe electrical condition with immediate effect.

A physical tamper is treated as an unsafe condition, and the electricity supply is immediately disconnected with a letter, duly signed by the officials as well as the owner/tenant.

In the case of the check meter principle, where tampering has been proven, an account is rendered with a 14-day notice period within which the customer is to pay or make due arrangements as per council's credit policy. The right to purchase electricity is immediately revoked by being blocked in the prepayment vending system.

In the case of no payment or arrangements as stipulated, a final notice is delivered, allowing an additional seven days grace, after expiry of which the electricity supply is disconnected.

Technical controls

All meters (prepayment and credit) are sealed with uniquely numbered seals (Fig. 7) belonging to the City of uMhlathuze. These are registered when issued to the technical staff and recorded as such. A special project was launched to remove all old seals still in use in order to conform to the new seal standard. Previous "misuse" of seals was eradicated in this manner.

Strict meter procedures must be in place. No unauthorised meters should or must be made available to any "corrupt" person out there, for the difference between an honest person and a transgressor is but a thin line.

An audit process must consist of at least two officials per audit team to assist the utility with the proven evidence, audit sheet / form data, signed by both and co-signed by the supervisor.

During the installation process of check meters, labelling, property versus meter, must be correct as this ensures that the crux of check metering is adhered to. Check meter and prepayment meter must correspond by registering electricity consumed in or at the same property/household.

Educate the customer

This project was and is no secret. It was and still is advertised to all the residents of the City of uMhlathuze. A special video has been made and is daily shown on a circuit video system at all the vending stations in order to sensitise all the customers against electricity tampering. A special drive with informative sessions was held prior to the launching of the project. The main drive is about changing a culture of non-payment.

Many informers are assisting council to identify new or unknown transgressions. These properties must not correspond to any pre-identified tampered properties in the pipeline to be processed. Informers will receive a monetary value only if the percentage result exceeds 50%. No lottery scheme is accepted whereby random properties are listed to be processed. Consecutive tampered properties will be addressed on merit if they form part of an informer's list.

Accolades and acknowledgements

This project has proven itself worthy of the effort and dedication of all the parties involved. Eskom has a national eTa award system, whereby any project/process that has proven to be successful is measured amongst those in the same category. The check meter principle won the esteemed eTa Award during 2003 for the residential category.

International recognition was given to the City of uMhlathuze, when the ex-city electrical engineer, Danie van Wyk [1], presented a paper as requested, on the subject in Australia during October 2004.

The Association of Municipal Electricity Undertakings (AMEU) and the South African Revenue Protection Association (SARPA) have been used many times as a platform to inform other utilities of the success of this project.

Principal author

Principal author: Dennis Cloete holds a National Higher Certificate (T4) for technicians in electrical engineering from the Natal Technikon. Municipal experience: 1997 appointed as a consultant town electrical engineer of the then, newly-established Ulundi Transitional Local Council. Since 1999 in charge of marketing,

Customer services, sales and revenue protections sections in the City Electrical Engineer's Department, City of uMhlathuze. deputy chair of the South African Revenue Protection (SARPA) of the Kwazulu-Natal branch. Member of RED 5: BP&S workgroup, communiqué workgroup and retail: customer services sub-committee as part of the restructuring of the electricity industry under guidance of EDI Holdings.

Reference

[1] D J van Wyk, (Pr Eng): Ex City Electrical Engineer, City of uMhlathuze. (Initiator of Check Meter Principle).




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Advanced metering infrastructure for residential and commercial customers

Automated meter reading (AMR) is a relatively familiar concept to most electricity supply utilities, but the term advanced metering infrastructure (AMI) will be fairly new to most utilities. NRS049 – *Advanced metering infrastructure for residential and commercial customers*, has been drafted and published to create a standard specification for AMI systems in South Africa. This paper will provide an overview on the requirements as listed in NRS049 for AMI in South-Africa.

by H P D Groenewald, Eskom

The AMI system incorporates an AMI master station from where the configuration and functionality of the system is controlled, a communication network, the AMI meters, a load switch (disconnect/reconnect/load limiting), the appliance (load) control devices (activated through the meter), a customer interface unit and optional interfaces to communicate with a mobile customer interface and to retrieve water consumption data.

The AMI master station provides connectivity to back-end systems including a billing system, connect/disconnect system, fault reporting system, meter data management system, tamper detection system (revenue protection), load management system and quality of supply system, and in the case of prepayment system applications, to the vending management system. Interfaces to these back-end systems are not specified and will be utility-dependent.

NRS049 specifies two AMI configurations: Fig. 1 depicts an AMI system where data concentrators are utilised. Fig. 2 depicts a system where the communication is directly to the meter (data concentrators excluded). The communication from the first meter is linked to other meters or it can be applied as a stand-alone application.

Functionality explained

The functionality of the AMI system as specified in NRS049 is explained by looking at the individual requirements.

AMI meters

The meter forms the basis of the AMI system

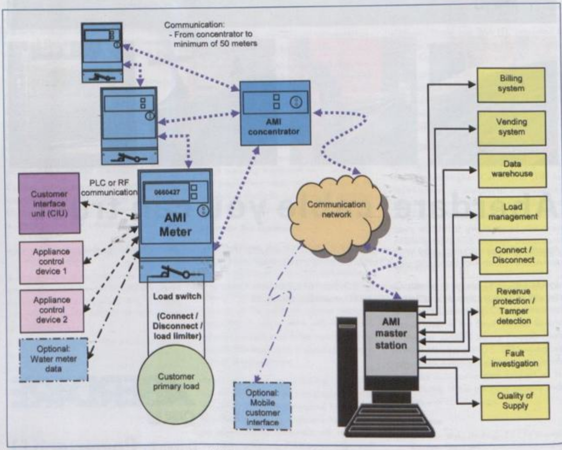


Fig. 1: AMI system overview utilising data concentrators.

at the customer installation. The functionality of the meter will primarily be to register active energy consumption data, it will relay the data through to the data concentrator or master station, it will relay commands through to the appliance control devices, it will send information through to the customer interface unit, and supply capacity control (load limiting) will be done through the internal connect/disconnect contactor.

The meter will typically be installed in a secure cabinet where the customer will not have access to it to prevent tampering or bypassing. Customers will have access to billing and other information through the customer interface unit.

The meter must be able to support a time-of-use tariff structure. NRS049 specifies that active energy consumption data must be stored on the meter as total register values (normal cumulative energy data) as well as half-hourly data. The data retrieval system (AMI master station) must be able to support both the retrieval of the billing register values as well as half-hourly data. It will be up to the electricity supply authority to decide if they will bill customers through meter register values or half-hourly values.

Apart from billing data it is also specified that the meter must be able to record different events such as when tampering is identified, supply outages, under and over voltage conditions, when disconnect commands were applied, when load control was done through the master station and for meter configuration changes.

Customer interface unit

The customer interface unit will be installed in the premises of the customer from where the customer can obtain first hand knowledge of his consumption data, energy cost, status of the appliance control devices, status of load limiting and all event alarms.

Appliance control

The appliance control device will connect and disconnect loads from the supply through commands sent by the meter and master station.

Under normal operating conditions the appliance control devices will be switched by the meter according to the time-of-use daily pattern. Loads will be switched off during peak time-of-use periods. The benefits will be to both the utility and the consumers. The utility will experience less loading during peak consumption periods and the customers will have load automatically removed from the peak periods which will save them energy costs.

The appliance control devices can also be operated from the master station in situations where there is severe strain on the capacity of the electricity supply system.

The status of the appliance control devices will be controlled by the meter and this information will in turn be sent from the meter to the customer interface unit.

The "turn-on" times of the appliance

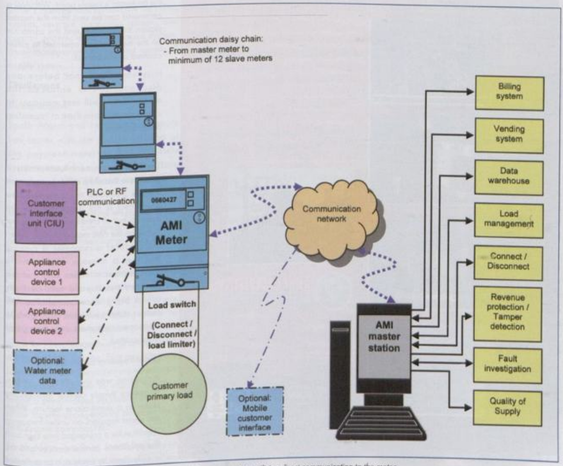


Fig. 2: AMI system overview utilising direct communication to the meter.

control devices will be scattered through a predetermined and randomised time maintained from the meter to avoid the creation of another peak loading condition at "turn-on".

Supply capacity control (load limiting)

The meter will control the supply capacity to an end user by monitoring the load for exceeding the set supply capacity limit. When this occurs the meter's connect/disconnect contactor will be opened and the supply to the customer will be interrupted.

The supply will be switched back again after a certain time and the load will be monitored again. If it still exceeds the limit then the supply will again be interrupted, but the duration of this second interruption will be longer than the previous. The interruption period will increment by a settable time period after every subsequent operation.

Under normal operating conditions the supply capacity control can be switched by the meter according to the time-of-use daily pattern. By implementing it this way it will ensure that the appliance control devices are not bypassed – if those loads are still connected to the supply then the supply capacity limit will be exceeded and the customer supply will be interrupted.

The benefits of supply capacity limiting during peak periods will again be to both the utility and consumer. The utility will experience less loading during peak consumption periods and customers can save on energy cost by reducing their loading at the high electricity price periods.

In a situation where there is severe strain on the capacity of the electricity supply system, then commands can be sent from the AMI master station to further reduce the supply capacity setting on the meter. The meter should first remove the large loads from the customer supply by operating the appliance control devices and then it will revert to the new setting.

Messages on the status of the supply capacity limit will continuously be sent from the meter to the customer interface unit. This information should be used by the customer to determine if additional loads must be switched off to avoid supply interruption.

Connect/disconnect

When in the past a supply had to be disconnected or connected due to change of ownership or non-payments, a technician had to be sent out to the installation to disconnect or connect at the customer's supply point. With AMI a command can be sent from the master station to the meter and the contactor on the meter will be operated to either connect or disconnect.

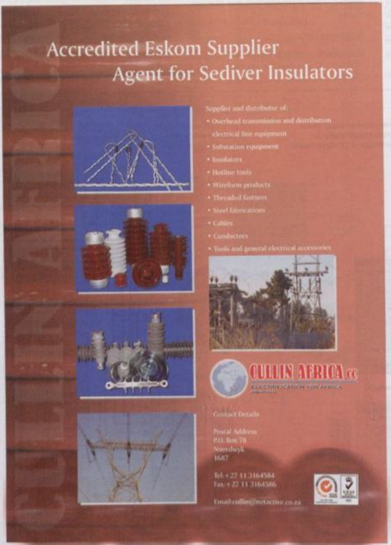
It is envisaged that before any disconnection is enforced the master station will sent messages to customers to inform them of impending disconnection.

Prepayment

The AMI prepayment functionality is different to that of the normal prepayment meters because the command to disconnect is not determined by the running-out of credit on the meter, but rather on the AMI master station. When the credit of a customer is running low, then a message will be sent to the customer interface unit that the customer must buy additional electricity or risk being disconnected. The AMI master station will issue commands to disconnect customers once their credit is exhausted.

Under-frequency supply control

An option was included for under-frequency supply control through the meter as a stand-alone feature. When the meter registers an under-frequency condition for a prolonged time then both the appliance control devices and the supply capacity limits can be activated to reduce loading.



The installation will be normalised again after the under-frequency condition is cleared and switch-back actions will be the same as for normal operation to again avoid the creation of a "turn-on" peak load.

Mobile customer interface

An option was included for the master station to sent messages through to customer mobile phones. This will typically be to inform customers of impeding disconnect or can be used when the supply capacity is to be limited beyond normal settings.

AMI master station

The master station shall provide for all the functionality as specified in the subsections above.

The master station shall also be capable of integrating into the utility's existing management systems and be capable of extracting data from the AMI system that is relevant to those systems in a secure and auditable manner. Examples of the utility's management systems are the billing system, revenue protection system, load control system, data warehouse system, asset management system and quality of supply system.

Challenges

Standardisation

South Africa and in particular Eskom has learnt with the implementation of pre-payment metering that propriety systems should be avoided to ensure interchangeability between suppliers in a certain area.

Most of the AMI systems employed in the world have their own propriety protocols and designs and interchangeability will be almost impossible.

Some of the major manufacturers have realised that there is a dire need for standardisation in this field and there are various initiatives taking place to standardise on communication protocols to allow for interchangeability of components at installed AMI systems. Pilot projects have been initiated where major manufacturers are working together to ensure that they follow a standardised approach which will allow for interchangeability between their AMI system components.

South-Africa needs to learn from those initiatives and adopt standardisation when implementing AMI systems.

Electricity Regulation Act

New regulations for electricity reticulation services have been published in the Government Gazette of 18 July 2008 which requires that end users with a monthly consumption of 1000 kWh and above must have a smart system and be on a time of use tariff by not later than 1 January 2012.

The definition of a smart system, as stated in the Government Gazette, is an electricity meter that allows for:

- Measurement of energy consumed on a time interval basis
- Two-way communication between the customer/end user and the licensee
- Storage of time interval data and transfer it remotely to the licensee
- Remote load management.

The electricity supply utilities are now in a predicament. It will not be wise to install propriety AMI systems because it defeats the objective for standardisation and can lead to costly replacement of AMI components before their normal service life has expired, yet they have to comply with the Act.

Electricity supply utilities will need to study the market carefully when deciding on AMI systems. Systems where no international standard have been adopted should be avoided.

System support

System support will form a fundamental component for the success of AMI in South Africa.

The skills of the electricity supply utility's meter installers and readers may not be adequate to support AMI equipment. Specialised skills will be required to support the commissioning of data concentrators, meters, appliance control devices, customer interface units and communication modems.

The continual maintenance of the equipment will again require specialised skills.

Utilities will need to establish a new central operation centre from where the AMI master station software will be controlled. Operators for the AMI master station need to be employed and trained.

Next steps

Most electricity supply utilities will at some stage have installed AMI at residential customers. The revised Act is forcing electricity supply utilities to speed-up their programs for the installation of AMI.

Utilities will now have to start with specifying their AMI system, follow a tender process, perform a proper evaluation of the systems and then install the equipment.

Specification of AMI

NRS049 - *Advanced metering infrastructure for residential and commercial customers* was created to ensure that uniform systems will be installed in South Africa. Electricity supply utilities can use the requirements of NRS049 as a basis for specifying an AMI system for their end users.

Evaluation of the AMI system

Adequate time must be allowed for a proper evaluation of equipment, communication and software. Some of the requirements of NRS049 are unique to South Africa and equipment may be newly developed and will thus not be "tried and tested".

It is envisaged that Eskom will require that equipment deemed to be suitable for installation be subjected to its accelerated environmental stress testing programme. Through this testing program the whole system will be extensively tested – equipment, communication, performance and software.

AMI systems which have passed the accelerated environmental stress testing will then be installed at large scale pilot programs, where their performance in normal field conditions will be evaluated.

Large-scale roll-out of AMI will follow thereafter.

Conclusion

There remain a lot of challenges for the successful implementation of AMI on a large scale in South Africa and utilities and industry need to work together to get the most optimal solution for South Africa.

NRS049 - *Advanced metering infrastructure for residential and commercial customers* was, as a first initiative for standardisation in South Africa, developed by the NRS working group and is now available to guide electricity supply utilities in their requirements for an advanced metering infrastructure.

References

[1] NRS049 (2008) - *Advanced metering infrastructure for residential and commercial customers.*

[2] Government notice R.773 (18 July 2008) Electricity Regulation Act (4/2006): Electricity *Regulations for Compulsory norms and Standards for Reticulation Services.*

Update and details of the Energy Conservation Scheme (ECS) and associated punitive tariffs

Since the establishment of the Power Conservation Programme (PCP) by the National Electricity Response Team (NERT), set up by the Department of Minerals and Energy (DME) following the emergence of the generation capacity crisis at the beginning of 2008, serious moves have been afoot by Eskom and the DME to develop an Energy Conservation Scheme (ECS), the details of which are only now beginning to emerge.

by Chris Yelland CEng, EE Publishers

The first sign was the issuing for public comment of proposed new regulations in terms of the Electricity Regulation Act, 2006, by the Department of Minerals and Energy (DME) in Government Gazette No. 31339 of 15 August 2008. These draft regulations closed for comment on 19 September 2008, and the final regulations are expected to be promulgated and in place by end October 2008.

Entitled "Electricity Regulations on Deviation from Approved Tariffs", they seek to empower the Minister of Minerals and Energy to deviate from the normal NERSA approved electricity tariffs and set various sector electricity saving targets in order to achieve an overall national electricity saving of 10%.

However, while these draft regulations are now in the public domain, electricity customers are generally unaware of what actually lies behind them, as well as the rules, details and price levels of the punitive tariffs being proposed by Eskom on behalf of the DME in order to achieve the national energy saving target.

While the ECS rules are not fully finalised, Eskom has indicated the intention for them to be in place by the end of 2008, for commencement of the ECS in early 2009. However, there is now some doubt as to whether this will be achieved.

The ECS rules and regulations will set specific electricity saving targets and electrical energy allocations for various customer categories and for all electricity customers greater than a defined size, as well as punitive electricity tariffs for those customers that exceed their electrical energy allocations.

Eskom has indicated that the thinking at this stage is for the ECS to apply to customers consuming more than 100 MWh per annum (i.e. customers with a maximum demand greater than about 20 kVA at a load factor of 0,6 and power factor of 0,95).

The intention is that in 2009 each customer to which the ECS applies will be given a monthly energy allocation (kWh) based on the requirement to achieve a specified electrical energy saving in respect of the customer's consumption during the period October 2006 to September 2007 (referred to in the ECS rules as the baseline period).

In terms of the latest ECS rules and thinking, for each customer class the savings that will be required of customers in respect of their consumption for the baseline period are: mining: 8%; agriculture: 8%; industry: 10%; commercial: 20%; residential: 20%; and government/state owned enterprises: 25%.

Failure to meet these savings (i.e. a customer exceeding its energy allocation) will result in punitive electricity tariffs in accordance with the ECS rules for that portion of the customer's electrical energy consumption in excess of its allocation.

In this regard there would be three applicable price bands for the first transgression of a particular month of the year under consideration, and then these price bands would be further multiplied by 1,5 and 2 (i.e. x1,5 and x2) for a second and third transgression respectively in the same year, as follows:

	Control band	Disincentive band	Punitive band
	0 - 2,5% above (1)	2,5% - 10% above (3)	> 10% above (5)
	0 - 1% above (2)	1% - 10% above (4)	
1st transgression	R2,80/kWh	R4,50/kWh	R9,00/kWh
2nd transgression	R4,20/kWh	R6,75/kWh	R13,50/kWh
3rd transgression	R5,60/kWh	R9,00/kWh	R18,00/kWh

Note 1: For customers < 10 MVA, the control band is 0 - 2,5% above allocation
Note 2: For customers > 10 MVA, the control band is 0 - 1% above allocation
Note 3: For customers < 10 MVA, the disincentive band is 2,5 - 10% above allocation
Note 4: For customers > 10 MVA, the disincentive band is 1 - 10% above allocation
Note 5: For all customers, the punitive band is > 10% above allocation

As an example, from the above and based on the present "normal" electrical energy price of about R0,50/kWh, it can easily be calculated that for a commercial customer that does not save the required 20%, but simply maintains its electrical energy consumption (kWh) in 2009 at the same levels as in the baseline period (October 2006 to September 2007), the electrical energy bill will be about 4,6x higher in the first month, then 6,4x higher in the second month, and finally 8,2x higher in the third month, as compared to that paid by the customer in the baseline period.

This is clearly intended as a big stick to punish those individuals and organisations that do not meet the electrical energy saving requirements of government and Eskom, and is aimed at changing their mindset and making them do things to save electricity that they would not voluntarily do.

In my opinion, however, the ECS as it currently stands may be missing the mark. I believe the real challenge is to reduce and remove non-productive, wasteful and inefficient electricity consumption from the system, without capping, punishing or limiting efficient electricity use and efficient growth of electricity consumption by the productive economy, which would otherwise compromise economic growth, job creation and growth in manufacturing output and commercial services that a developing economy so desperately needs.

There are now talks in progress about phasing in the energy saving targets, and the customers that are required to participate in the ECS, and this may help soften the impact on the economy and allow electricity customers time to make the appropriate investments in energy efficient equipment, and to change their behaviour.

I believe that before launching forth with the planned ECS as a fait accompli, the DME and Eskom should embark on a broad-based, open and transparent consultation, discussion, education and communication programme in order to take the public and electricity customers along with them. Otherwise there may be a significant negative backlash.

The current proposals undoubtedly have enormous economic impact and pose significant implementation and administrative challenges. It remains to be seen whether the DME and Eskom will be brave enough to announce and launch the proposed ECS before the general election in 2009!

ADDAX Prepayment achieves "SMART" Metering Status

While the composition of electricity industries varies around the world the drive remains to provide cost effective and clean energy, which is a key issue to the numerous challenges facing the world today. One huge step in this direction is easily achieved through **Demand Response** and **ADDAX** AMI technology has exceeded this requirement with their new "SMART" single and poly-phase meters that are fully **STS** compliant and certified.

Power Measurement & Distribution Holdings is unlocking **E**nergy **I**ntelligence with the **A**dvanced **M**etering **I**nfrastructure of **ADDAX.net** providing a unique "SMART" Grid. Together with this "SMART" Grid, **ADDAX** "SMART" meters are facilitating dynamic **Demand Response** thereby unlocking additional power capacity, while non-technical losses are identified and fraud is eliminated thus deferring new investment into generation, transmission and distribution infrastructure.

ADDAX STS meter features:

- √ DLSM/COSEM support
- √ Remote connect/disconnect
- √ Powerful Time of Use engine
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- √ Dual metering modes of credit and STS prepayment metering in a single package
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- √ Skew Voltage, Max/Min Voltage, Current Limit, PF/W & Temperature
- √ measurement
- √ DSM: Built-in auxiliary intelligent relay with remote control and unique configurable switching schemes (weekday, holiday, non-standard day)
- √ Two-way communication via existing LV(0.4kV) & MV(6..35kV) power line
- √ Support integration of meters of other resources

Integrated AMI Meters
Two-Way LV + MV PLC
DLMS/COSEM over TCP/IP
S-FSK + OFDM
STS (NRS: 009-6-6/ 009-6-7/ 009-6-8/ 009-6-9)

ADDAX Disconnect Intelligence

Switching Due to Consumer Actions	Switching Independent of Consumer Actions
Active power out of limits (Configurable)	Inadmissible internal temperature (Configurable)
Inadmissible PF (Configurable)	Inadmissible skew phase voltage (Configurable)
Current out of limit (Configurable)	Inadmissible low/high network voltage (Configurable)
Differential current out of limit (Configurable)	Switching off from central control

ADDAX Delivering Intelligence at the Wire-End

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Future strategy for the implementation of smart metering with ripple control

Ripple control is a well-established technology that has been in reliable use world-wide for over 50 years. It uses the electricity distribution network for the one-way transmission of the control signals from the central MV or HV injection point down to the receivers mounted in the LV network, where they directly switch the actual loads to be controlled.

by Ian Robinson, Robmet Meters

An important aspect of this that needs to be stressed is that the complete transmission path belongs totally to the utility, and is not dependant on the actions or pricing strategies of third party suppliers. Ripple control is used for a large number of different switching functions, but in South Africa is used predominately for the dynamic load control of the utility's network by switching hot water geysers.

Because a modern ripple control receiver can be fitted with more than one load switch, it can also be used for functions such as the control of swimming pool pumps, time of use (TOU) meters, and load limiters.

Smart metering, on the other hand, is characterised by its ability to offer two-way communication between a central point and the individual meters. The concept of smart metering has been in use for many years for the collection of billing and load profile data from large power users, where the high capital cost has been justified by the many benefits obtained when applied for the metering of large polyphase loads, where the monthly bills are in the order of many thousands or even millions of rands.

However, smart metering is only now being introduced internationally for the metering of domestic customers, and various trials and pilots are in operation throughout the world.

It should be stressed that smart metering is being introduced overseas for different reasons than those envisaged in South Africa.

Amongst these reasons is the fact that networks are being "unbundled", which requires that meter reading should be carried out monthly instead of once per year, and manual meter reading costs are far higher overseas than in South Africa.

Also, smart metering is not normally introduced for the dynamic load control of hot water geysers. The reason is that in North America and Europe (where the majority of the trials are taking place) domestic hot water is obtained via a secondary cylinder in the oil-fired or gas-fired central heating system.

Modern ripple control systems

The main characteristics of modern ripple control systems are:

- The use of lower control frequencies than in the past, typically below 300 Hz, so as to improve the propagation characteristics of the control signal throughout the controlled network.
- Injection of the control signal at far higher network voltages than in the past (up to 150 kV), so enabling large networks to be controlled from just one injection point instead of the large number of injection points that were previously necessary in the case of decentralised 11 kV injection.
- The use of modern communication protocols, which enable far more switching commands to be transmitted than in the past, so that the load can be divided into a larger number of smaller groups, so giving better switching resolution.
- The use of these modern communication protocols also makes it possible to transmit virtually as much information as is transmitted by smart metering systems.

  This information includes the transmission of time signals (not just a synchronising pulse) as well as tariff control signals and remote switching of load limiters. Switching programs stored in the receivers can also be remotely reprogrammed, without the need to visit every receiver in the field.
- Modern ripple control systems are able to carry out an emergency shed function within 10 seconds, so assisting in maintaining system stability when a network disturbance occurs.

Government legislation

We are all aware by now of the recent regulations issued by national government with regard to the implementation, inter alia, of the remote control of various loads together with the introduction of smart meters for certain customers.

Notice R773 was issued in July 2008, and specified that all electric geysers that do not incorporate a solar water heating facility, as well as any heating, ventilation and cooling systems on the consumer's premises, plus swimming pool pumps and heaters, should be fitted with a facility to remotely control the supply of electricity to these items.

These requirements do not apply if a "smart system" is installed, which can remotely reduce or increase the supply of electricity to the consumer. At the same time, in the case where the customer consumes 1000 kWh or more per month, it is required that the customer must be metered by a TOU meter, and that a "smart system" must be installed.

It is furthermore a requirement that all the above must be in place by 1 January 2012.

Then in August Notice R842 was issued, which brought the 1000 kWh per month limit down to 500 kWh per month.

In September Notice R1190 was issued, which advised that Notice R842 had been withdrawn.

Accordingly, it would appear that Notice R773 is now still valid.

It should not be forgotten that Notice R773 stipulates that all electric geysers that do not incorporate a solar heater, as well as any heating, ventilation and cooling systems, plus swimming pool pumps and heaters, still need to have some form of control even if a smart meter is not installed, if the consumption is less than 1000 kWh per month.

While most customers with all of the above loads will probably be consuming more than 1000 kWh per month, and so be covered by the requirement to have a smart meter installed, there are many customers with just a geyser who consume less than 1000 kWh per month, and therefore fall below the requirement to be on a time of use tariff and have a smart meter installed.

In any case, the revenue collected from these customers will not justify the installation of a smart meter, so there is clearly a need for a control system that will cover these many thousands of customers.

Smart meters

It is a matter of record that there are a large number of smart metering pilots and projects in progress in many countries throughout the world. It is probably not so well known that virtually every country has a different definition of what constitutes a smart meter, as they all have different requirements.

There is also no standardisation on the method of communication with the meters, with some countries preferring power line carrier (PLC), while others prefer GPRS, whilst still others prefer a dedicated RF network.

A South African Working Group has produced a South African standard for a smart meter (NRS 049), but this is specific to South Africa, so could result in a far more expensive solution than meters developed for the various overseas markets.

At the same time, NRS 049 is very vague when it comes to the support infrastructure that will be necessary in order to integrate the meters into the billing and administration systems. Experience overseas is that the cost of these "head-end" systems is more then the cost of the total meter hardware in any project.

It is also interesting that NRS 049 does not specify the actual means of communication with the meters, nor the communication protocol to be used: these will be covered by future editions of the specification.

It is therefore extremely likely that the same problems will occur as when prepayment meters were first introduced into South Africa, leading ultimately to the introduction of the STS standard.

Concerns over smart meters

Below are some concerns that the writer believes need to be considered before there is a dash to install over 3-million smart meters in South Africa by January 2012:

Some technical concerns are:

- Smart metering is still a new technology, with reliability and life-cycle times still to be proven.
- No international standards have been formulated yet.
- Smart meters are being introduced overseas, mainly for AMR and tariff purposes. They are not being used for dynamic load control, as this requirement does not exist overseas.
- It is still to be proven whether they are suitable for dynamic load control. AMR and tariff control are not time-sensitive functions, whereas dynamic load control requires an emergency shed capability of better than 10 seconds.
- NRS 049 envisages that most smart meters will be mounted as a retrofit to the existing electromechanical meter, i.e., in the meter box which is typically outside the house.

At the same time, NRS 049 requires that the smart meter should have the ability to control devices such as geysers and swimming pool pumps via commands sent to "intelligent appliance control devices situated at the appliances".

What are these "intelligent control devices" and have they been fully tested in the field?

Some cost concerns are:

- The typical installed cost of a smart metering project, based on overseas experience, is at least R3500 to R4000 per metering point.

  For the South African application, we need to add either the cost of digging up the customer's driveway to lay the additional multi-core cable from the meter box to the DB board, alternatively the cost for a radio link to the DB board or the actual appliances.

  A realistic figure for either alternative is at least R1000 per customer, so giving a total cost of R4500 to R5000 per meter point.

  These figures are not unrealistic. For example, on a recent tender for a smart metering project involving 80 000 meters, one of the tenders quoted a total price of R650-million, ie more than R8000 per meter point.
- Government Regulation R.773 states that smart meters must be introduced for all customers consuming more than 1000 kWh per month. Exact figures are not available, but it is likely that there are more than 3-million customers in South Africa consuming more than 1000 kWh per month.

  Multiplying 3-million customers by an average of R4500 to R5000 per customer gives a total cost of R13,5-billion to R15-billion.

  Where will this money come from?

  At least 95% of these customers are supplied by the municipalities. However, municipalities already have severe funding problems, as highlighted at the recent Maintenance Conference.

  Help is unlikely to be forthcoming from Eskom, as they are also suffering from a serious lack of funding even to build new power stations.

  Even Eskom's DSM fund is virtually empty.

  The question must therefore be repeated: where will this funding come from?
- Most smart meter systems rely on the GSM/GPRS network, either directly or indirectly.

  As a result, while the costs for reading meters will probably be acceptable to municipalities, the annual costs for dynamic load control will be excessive.

  For example, and using the case of a municipality with 300 000 customers, using direct GPRS communication with each meter, and assuming a cost of only 10 cents per message, with 20 messages per day, this would result in recurring running costs of over R200-million per year.

Some practical concerns are:

- Working samples of meters in accordance with NRS 049 still have to be designed, manufactured, type-tested, approved and then field-trialled before installation can commence.

  This means that it is extremely unlikely that all 3-million or so will be available to be installed by January 2012.
- The installation process will require a large number of qualified electricians, who do not currently exist.
- There are currently around 20 000 meter readers gainfully employed reading meters.

  Most of these will be left jobless when fully automatic smart metering systems are deployed.

Proposed solution

The paper proposes a hybrid solution:

- Using the low cost, and proven reliability and speed of operation of modern ripple control systems, for the "forward" control direction.
- Using standard smart meters to provide TOU and data logging functions, but read by meter readers using the same handheld units that are currently used for the manual entry of meter reading data, but now fitted with optical couplers so as to read all the data stored in the meter fully electronically and therefore accurately via the optical port of the meter.
- Space would be provided in the smart meter for the future addition of a communication module, should it be desired to implement fully automatic operation of the system at a later date, when communication methodologies and protocols have matured.
- The use of ripple control in the "forward "direction would also enable all those customers falling below the 1000 kWh per month consumption level, but still having a geyser, also to be controlled, at minimal extra cost.

The benefits of this proposal include:

- Well-proven: ripple control is a well-proven technology that is already in widespread use in South Africa so that its technology is well understood.
- Quick delivery: because ripple control uses existing technology, there is no long lead-time while the system is being designed, approved, and field-trialled. Receivers are available for immediate delivery.
- Fast response time: ripple control is the only system that enables an emergency shed function to be carried out in less than 10 seconds.
- Fully compliant with Notice R.773: all the requirements of R.773 are fully complied with.

  The requirement for two-way communication is complied with by means of the meter reader, who would bring back the data in electronic format.
- Fully under the control of the utility: the complete system would be owned by the utility, without the need to involve third parties such as GPRS providers.
- Direct control of geysers: the ripple control receiver can be mounted in the existing DB board for the direct control of the geyser (plus swimming pool pump and heating systems) without the need for radio links from the meter box to the DB board or the inconvenience of digging up the customer's driveway.
- Low cost: typically, the capital cost of the proposed hybrid solution should be between one third and one half of the cost of a conventional smart meter system.

  At the same time, the running costs would be minimal, as there would be no expensive monthly fees to be paid to third party suppliers.
- Give time for communication methods and protocols to mature: sufficient time would be available for both the method of communication as well as the protocols used to mature, without making possible mistakes which are then expensive to rectify.

Summary

Ripple control is a well-proven existing technology, which is available for immediate delivery, without needing time-consuming design and approvals processes. It is the only proven system able to provide dynamic load control functions, with an emergency shed time of better than 10 seconds. Combined with already existing smart meters with a TOU capability and load limiting functions, the hybrid solution complies with all the relevant requirements in an extremely cost-effective manner.

DMS - does South Africa need a paradigm shift?

The term "demand side management" (DSM) was first used in the United States in the early 1980s and later adopted in the United Kingdom, Europe and Australia. In terms of DSM implementation in South Africa, the concept is still relatively new. While Eskom formally recognized DSM in 1992, the first DSM plan was only produced in 1994. Since then Eskom has spearheaded many DSM initiatives and continues to lead the way in promoting the efficient use of electricity. The principle of DSM is therefore not new to the electrical fraternity and in the interests of energy conservation, should without question, both be well understood and supported.

by Viv Cohen, CBI-electric - Low Voltage

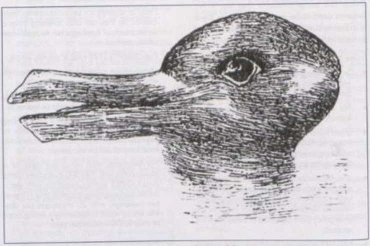

Fig. 1: Kuhn's duck-rabbit optical illusion.

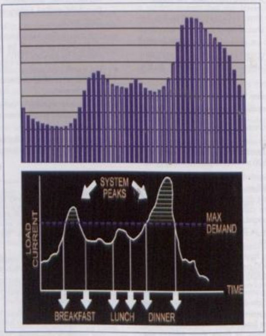

Fig. 2: Load profiles

The Eskom DSM website [1] defines demand side management as the process whereby an electricity supplier influences the way electricity is used by customers. "DSM means the planning, implementation and monitoring of end-user's activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand."

The website goes on to define electricity demand as "the amount of electricity required by all electric equipment operating at one time in a building, an area or a city. The prime objective of DSM is providing constant, efficient use of electricity, resulting in lesser amounts of electricity during peak times, thus managing the demand effectively. If electricity is managed in this way, the demand is more consistent and consequently electricity suppliers are more able to meet the requirements of all of its consumers."

In hindsight it is unfortunate that on the same website, one of the benefits of DSM is listed as:

"Delaying the requirement for infrastructure capital investment."

It is equally unfortunate that this website describes the key benefit of DSM as the efficient use of electricity, without influencing the customer production and satisfaction levels, resulting in significant cost savings for the provider and thus the consumer as well.

As a consequence of the government and Eskom's self-inflicted power crisis, while the general public may not necessarily be familiar with the acronym DSM, it is the general public, commerce and industry that have been subjected to the costs and inconveniences of "load shedding".

Again, with the benefit of hindsight, our favourite utility may wish to consider rephrasing the comments:

- *"without influencing the customer production and satisfaction levels"* and
- *"resulting in significant cost savings for the provider and thus the consumer as well"*

The obvious question that needs to be asked is:

Fig. 3: Load shifting devices.

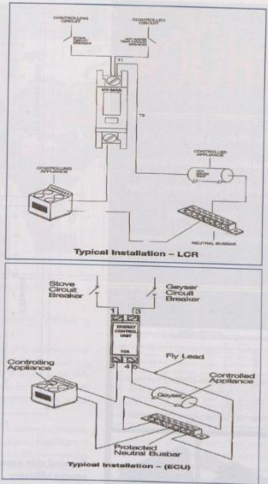

Fig. 4: Typical installation of consumer load and energy control devices.

When and how can the consumer expect to benefit from these "significant cost savings"?

Paradigm shift, [2] sometimes known as extraordinary science or revolutionary science, is the term first used by Thomas Kuhn in his influential 1962 book *The Structure of Scientific Revolutions* to describe a change in basic assumptions within the ruling theory of science. It is in contrast to his idea of normal science.

The term "paradigm shift" has found uses in other contexts, representing the notion of a major change in a certain thought-pattern - a radical change in personal beliefs, complex systems or organisations, replacing the former way of thinking or organising with a radically different way of thinking or organising.

Kuhn used the duck-rabbit optical illusion to demonstrate the way in which a paradigm shift could cause one to see the same information in an entirely different way (Fig. 1).

Paradigm shifts tend to be most dramatic in sciences that appear to be stable and mature, as in physics at the end of the 19th century. At that time, physics seemed to be a discipline filling in the last few details of a largely worked-out system. In 1900, Lord Kelvin famously stated, "There is nothing new to be discovered in physics now. All that remains is more and more precise measurement." Five years later, Albert Einstein published his paper on special relativity, which challenged the very simple set of rules laid down by Newtonian mechanics, which had been used to describe force and motion for over three hundred years. In this case, the new paradigm reduces the old to a special case.

In the later part of the 1990s, 'paradigm shift' emerged as a buzzword, popularised as marketing-speak and appearing more frequently in print and publication. It is sometimes referred to as abused and overused to the point of becoming meaningless.

"Paradigm shift" is however a meaningful term that may be appropriate in the context of the present power crisis in South Africa together with the high-handed approach that has been used to threaten consumers with power cuts or load shedding if they "do not reduce electricity consumption".

It is not impossible that a radical change in personal beliefs may be necessary to replace the former way of thinking or organising with a radically different way of thinking or organising, both from the electricity utility's and the consumer's points of view.

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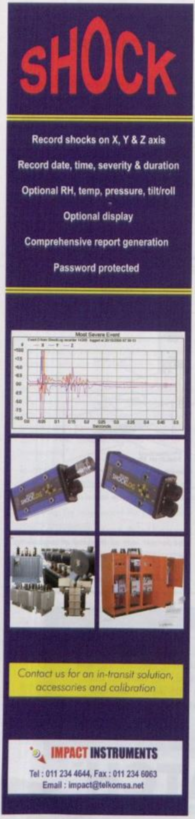

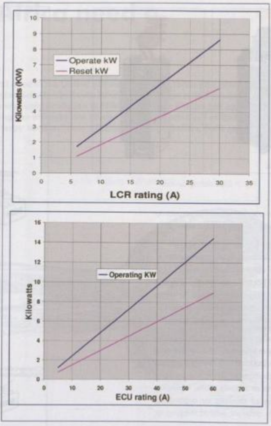

Fig. 5: Operating characteristics of load shifting devices.

Demand side management and energy efficiency

It is well known and generally accepted that demand side management includes two fundamental parameters. These include:

- Energy efficiency
- Maximum demand control

Both of these are related to the efficient use of energy.

Energy efficiency relates to the saving of power (watts). Some typical examples include:

- Energy efficient compact fluorescent lamps (CFL)
- High efficiency motors

Energy efficiency motivates the users of electricity to consume less electrical power.

The efficient use of energy relates more to load management.

Load management addresses three related parameters:

- Load shifting.
- Peak clipping.
- Valley filling.

Load profile

In electrical engineering, a load profile is a graph of the variation in the electrical load versus time. A load profile will vary according to customer type (typical examples include residential, commercial and industrial), temperature and holiday seasons. In the electricity generation sector, a load curve is a chart showing the amount of electricity customers use over a period of time. Electrical utilities and generation companies use this information to plan how much power they will need to generate at any given time.

Conferences on generation and the power crisis

Two highly successful South African Institute of Electrical Engineers (SAIEE) events were recently held at the Eskom College in Midrand on 11 February and 19 February 2008. Both events, "Power Crisis Coping Forum" and "Generation Conference" directly and indirectly addressed the extremely topical subject of the power crisis.

One question that remained unanswered after both events related specifically to the question of the Eskom load profile control. Also not fully explained was the load shifting programs that would be used in achieving such control.

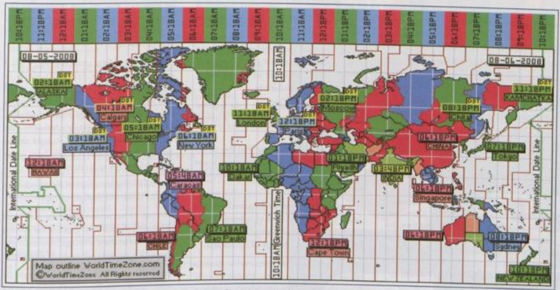

Fig. 6: International time zones.

Pursuant to these two events and in recognition of the need to further address that question, the SAIEE hosted a third event in the form of a breakfast talk [3] on 25 March 2008 at which Andrew Etzinger, Eskom's distribution general manager (demand side management department) was invited to present his views and deliver feedback on the Eskom DSM programme.

The theme of Andrew's talk was to open and close his presentation with, as he called them, six "tough questions". The six questions were:

- How will the power conservation programme (PCP) be implemented?
- Is there a role for utility-driven DSM after introduction of the PCP?
- Is there a role for load shifting programmes given that energy efficiency is a priority?
- How do we entrench a savings culture in South Africa?
- How do we best capture opportunities presented for business development and job creation?
- What policy and regulatory changes are required to improve effectiveness of DSM?

It was the third question in particular that caught this writer's attention: Is there a role for load shifting programmes given that energy efficiency is a priority?

Considering the unfortunate situation that this country finds itself in today, all of Eskom's efforts in achieving its PCP are both understandable and necessary. However, it is within the third question that a disturbing message is revealed.

A comment made during the presentation exposed an alarming misconception that may exist in some quarters of our favourite utility. That perception is that Eskom's load profile is "relatively flat".

This then begs the question "Relative to what?"

Until proven otherwise, it is suggested that until the load profile of Eskom or of any other electricity utility is shown to be truly "flat", opportunities exist for improving both the utilisation and economics of this scarce energy resource.

It is conceded that the Department of Minerals and Energy's recently published Regulations of the Electricity Regulation Act, 2006 incorporates ambitious requirements for licensees to include facilities allowing it to remotely control the supply of electricity to water heating geysers, heating ventilation and cooling systems as well as swimming pool drive and heating systems [4].

However in consideration of the less than perfect history and experiences in regard to licensee investments into ripple control systems for water heating geysers, any further investment into any system that is dependent on a sophisticated management and control backbone remains questionable. The chronic national shortage of skills in itself must cast some doubt on the sustainability of such measures.

While centralised remote switching of the electricity supply to disconnect selected loads certainly does provide electricity utility licensees with the opportunity for bulk load shedding, this undemocratic process is unlikely to curry favour with the general electricity-consuming public.

It is unfortunate that only limited recognition has been given to unobtrusive, proven devices that have been used and are available to South African utilities and consumers for at least three decades, that passively and automatically achieve the load shifting function without requiring any backbone infrastructure, control or maintenance.

These clip-mounted "load control relays" [5] are designed to control any non-essential load. They are designed to fit easily into standard residential, commercial or industrial panel boards and operate on the principle of monitoring any peaking loads (of which cooking loads are a prime example) and shedding any non-essential loads. It becomes apparent the any load shedding is effectively under the control of the user through their own electricity usage patterns and actions.

Particularly in the case of thermal storage loads such as water heaters or underfloor heating the function of these devices, while being automatic, is unobtrusive and far less likely to encourage tampering and by-passing.

The objective and function of both LCR and ECU devices are the same. Both include "controlling" and "controlled" circuits. The differences between the two devices are that the ECU is electronically operated with high accuracy whilst the LCR is thermally operated with longer time constants, but more cost-effective. "Controlling" loads typically include peaking load appliances such as cooking appliances. "Controlled" can be any type of load, but the most unobtrusive applications use thermal storage type of loads such as water heaters and underfloor heating.

Typical operating kilowatt and resetting kilowatt characteristics for each of these devices are shown in the Fig. 5.

It is important to understand that neither of these devices is intended to save energy costs. Their primary function is to control peak demand. The major benefit of these devices is to the electricity supply utility, rather than to the consumer.

Having said this, the consumer still may enjoy several advantages including:

- Water heater (geyser) load shedding is limited to short periods, for example while cooking.
- Use of additional geysers or heating without requiring supply or installation upgrading.
- Elimination of any applicable maximum demand charges.

While the promotion of power conservation is admirable from a utility which it is assumed is in the business of earning revenue from the sale of its product (electricity), it should not be forgotten that load shifting, when carried out effectively and economically, does not result in the loss of sale of a single unit of electricity.

After all, despite the present power shortage, it becomes easy to lose sight of the fact that electrical utilities are actually in the business of selling electricity!!

The major benefit to utilities is that peaking load usage is automatically delayed to individual off-peak periods. There is also a major benefit to both utilities and consumers through a consequential reduction in maximum demand costs and penalties.

Sequential load shedding with prioritising is also easily achievable through the use of multiple series connected devices in higher load-consuming installations.

Both government and Eskom have together succeeded in creating the power shortage situation.

In this time of crisis it is hoped that they do not again fail to derive the full benefits of both power conservation and load profile control through load shifting.

In recognising the benefits to be gained from load profile control, in this time of national crisis, a window of opportunity has arisen in which a brave government can cut through all the red tape.

In this time of identified need, we can for once afford to behave a little undemocratically, through the decloration of a national emergency. Of course there will be those who will find all sorts of reasons why we should not follow the rest of the world in introducing a much needed time zone differential for our large country that spans up to 15° of longitude. Of course there will be objectors who will find reasons for our people not to benefit from the advantages in quality of life that could be gained from daylight saving.

From the world time zone map Fig. 6 [6] it is interesting to note that South Africa, in the interests of retaining a single national time zone, is already out of phase with many African countries sharing similar longitudes. Even our close neighbour Namibia has recognised the benefits of daylight saving through the introduction a one hour winter time shift relative to South Africa.

And the costs associated with the introduction of time zones and daylight saving?

Minimal - if we achieve this under a national emergency situation and avoid all the working groups, committees meetings, referenda etc. that such a proposal will no doubt precipitate.

So what if some of the concerns are real. So what if some of the doomsayer's predictions are justified? After a few years, (again at minimal cost), once Eskom's efforts have managed to get us over this electricity shortage period – we can very easily go back to where we were!

Alternatively, what if we actually come to enjoy the benefits of daylight saving?

Powertech Otokon awarded contract for supply of precision metering solutions

Powertech IST Otokon was recently awarded a major contract to supply Eskom with advanced metering technology. The contract runs for an initial three-year period with an option to extend it. The aim of the project is to upgrade existing Eskom Transmission metering installations, which have reached the end of their "design life", and to provide new equipment for those installations currently unequipped.

In order to meet the customer's requirement, a modular solution is implemented, using a blanking system for unused slots. The cubicle design is functional yet aesthetically pleasing, which is emphasized by the Essailec rack-mounted metering units and the use of PK2 test block for voltage and current circuits.

The Power Logic ION8800 Class 0.2S meters are used in a Main/Check configuration, ensuring that no data is lost in any foreseeable system failure situation. These devices have extensive I/O capability, and in the case of metering at a point other than the point of power exchange, the Line Loss Compensation functionality may be required. A wide range of Power Quality measurements are made including current and voltage harmonics, transients, sags and swells, flicker and waveform capture. With various onboard communication interfaces, the customer is able to utilize various media to access both metering and power quality data.

The Power Logic ION Enterprise software, when used with Power Logic ION meters, is a complete power management solution. It allows the management of energy information from installed metering and control devices, and is seamlessly shared with all stakeholders and with other business and automation systems. The Web-enabled access gives each user a personalized view of timely and relevant information.

Powertech IST

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Advertorial

Conclusions

In order to conclude this article, firstly, we need to go back and answer Andrew Etzinger's third question posed in his breakfast talk of 25 March 2008. The question was:

"Is there a role for load shifting programmes given that energy efficiency is a priority?"

That answer is easy, since I believe this to be an emphatic yes!

The Department of Minerals and Energy has certainly indicated its commitment and intent in regard to DSM through the 18 July 2008 publication of Regulation No. R.773.

However publication of those regulations leads to some serious concerns in regard to both the methodologies being implemented as well as the not insignificant costs that would be incurred by licensees in compliance with these regulations which, by the way, only have an implementation date of 1 January 2012.

The time has come to supplement preconceived ideas and methodologies and to consider a "paradigm shift" in fundamental thinking. The time has come to:

- Implement additional means of load profiling control without having to wait until 2012.
- Not to restrict load profile control actions to be solely under the control of the utility.
- Improve consumer relationships through load shedding on a more democratic basis.
- Recognise the proven technologies of individual consumer peak load control devices.
- Use the window of opportunity to introduce daylight saving seasonal time changes.
- Seriously consider the introduction of at least a second time zone in South Africa.

It does not matter how many more electricity power stations are approved, purchased, built and brought on line. More than a shortage of generation power, South Africans need to learn how to conserve our precious resources. We must also never forget the amount of water consumed in the generation of electricity. One of the most powerful energy conservation tools is the levelling of the national electricity load profile curve.

Notwithstanding the relative calm due to reduced power outages during the recent winter months, neither South African consumers nor our electricity supply utilities can afford any degree of complacency. Throughout history, authors have created or cited quotations relating to the opportunity in adversity.

This South Africa of ours has been offered one of these rare opportunities not only to learn, but to benefit from our adversity. But nothing happens automatically. In order to make things happen, it is possible that some difficult decisions might need to be made. And these difficult decisions will almost certainly need an opening of minds, even starting from a clean sheet.

Yes, it may be difficult to break away from long-standing, deeply-entrenched preconceptions.

All South Africans, government, Eskom and consumers, in the interest of seeing some rapid results need a paradigm shift in their thinking. Our opportunity in adversity has arrived!

References

[1] www.eskomdsm.co.za
[2] Wikipedia
[3] WattNow, June 2008
[4] Government Gazette Notice No. R.773 18 July 2008
[5] CBI-electric Low Voltage
[6] Map outline, WorldTimeZone.com

Load shedding in the South African context

On 18 January 2008 load shedding was introduced to the country by Eskom. At the time the demand on the system exceeded the system capacity and threatened the system stability. Load shedding became part and parcel of daily living in South Africa. Load shedding as a solution to the problem is predominantly based on the Brazilian experience and measures taken there to address the situation.

by L G Kritzinger, Centlec (Mangaung)

Why did we have load shedding in South Africa?

The fact that since 18 January 2008 a shortage of electricity was experienced in the country poses the question: why? A number of explanations can be given:

- It was a possible mechanism by Eskom to manipulate the outcome of their proposed 53% tariff hike in their favour.
- The actual price of electricity in the country is too low due to incorrect historic tariff increase.
- The national government failed to allow the construction of new power plants since 1997.
- The actual consumption of electricity users is too high due to the low tariff and lack of understanding that it is a scarce resource.
- Eskom failed to alert the general public and business to the actual shortage of generation capacity when the government did not respond to their request to build new plant.
- The economy has grown more than expected in line with the global economic growth.

Although there is truth in probably all the above-mentioned reasons, only one of them would be discussed in more detail in the following paragraphs – customers are using too much electricity.

According to an article written by Kevin Lings, the World Bank classifies economies into four categories:

- High income (more than $11 115 per person)
- Upper middle income ($3596 to $11 115 per person)
- Lower middle income ($906 to $3595 per person)
- Low income (less that $906 per person per year)

South Africa is currently classified as an upper middle income economy. In Fig. 1 the GDP per person for upper middle income countries is reflected. South Africa is 15th highest out of the 23 countries listed.

When the electricity consumption is considered, South Africa has the third highest consumption out of 27 countries listed as depicted in Fig. 2.

Based on this information, the conclusion is drawn that South African consumers should be able to save between 10 and 15% on the use on electricity.

The availability of electricity can be addressed in one of two ways: either more electricity needs to be made available or the consumption must be lowered. Due to the fact that new

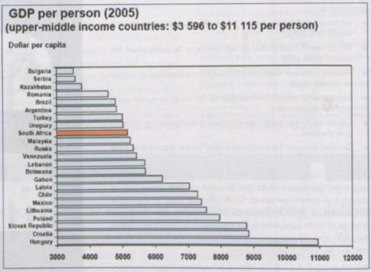


Fig. 1: GDP per person for upper middle income countries.

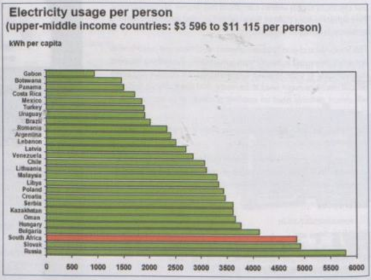
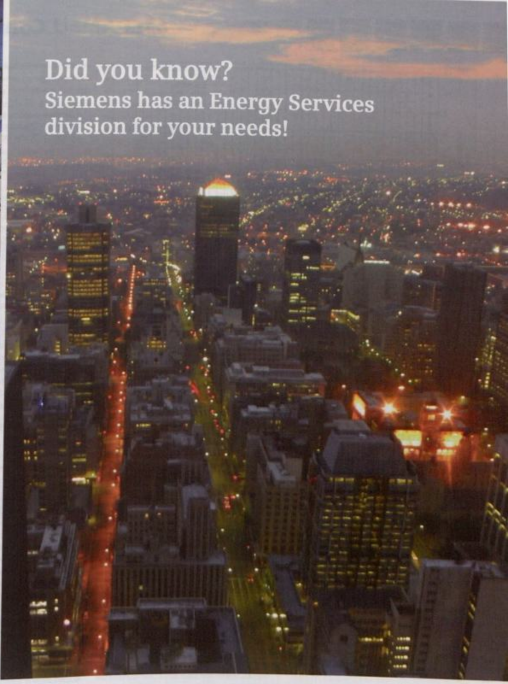


Fig. 2: Electricity usage per person.



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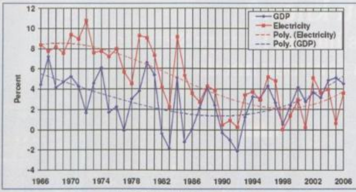

Fig. 3: GDP and electricity consumption.

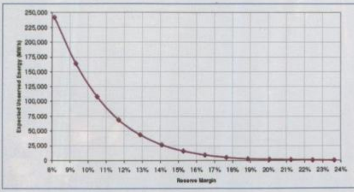

Fig. 4. Effect of reserve margin on unserved energy.

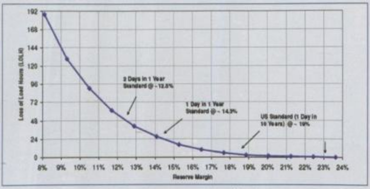

Fig. 5. Effect of reserve margin on loss of load hours.

generation plant would take between five to eight years to come on line, there is currently no alternative to South African customers but to save on the consumption of electricity.

In terms of the Energy Security Master Plan Electricity 2007- 2025 released by DME there is a close relationship between GDP and electricity consumption which is reflected in Fig. 3.

From this graph it can be seen that the GDP follows the electricity consumption pattern, and was historically lower than the electricity consumption. However, this has changed since 2003 when the GDP exceeded the electricity consumption.

Another factor to be taken into account is the cost of unserved energy. The latter was defined as "The value associated with each unit of unserved energy or a blackout". As the reserve generation margin, which is currently at 6% is increased, the likelihood of black-outs gets less as is depicted in Fig. 4.

Another aspect linked closely to the cost of unserved energy, is loss of load hours. In terms of international standards loss hours become almost insignificant as the reserve margin increases to 19%. (Fig. 5)

It can be seen that there are a number of factors to be taken into account on the shortage of electricity. In order to address the shortage of generation capacity, a number of national interventions are required:

- The price of electricity is too low and therefore electricity is not utilised as a scare resource. The price therefore needs to be increased to change behaviour patterns.
- The generation capacity cannot be increased in the short term. Therefore the only alternative is to lower energy consumption.
- The generation safety margin can however be increased substantially if the system demand is lowered. The latter can be achieved by dividing the country into four time zones in order to create a difference between Durban on the eastern side of the country and Cape Town on the western side of the country.
- The skills shortage in the country needs to be addressed and the value of technical staff be understood in rendering services to the country at large.

This measure would have the impact of lowering the system peak by as much as 880 MW. Eskom indicated earlier that 3000 MW is required to increase the safety margin by 13% from the current 6% to 19%. Of the 13% required, 3,8% can be achieved through the time zone implementation.

How load shedding was done

A conflicting message came from Eskom as to what must be saved in January – maximum demand, energy or both.

Initially load shedding was done in an uncontrolled fashion. There was no prior warning and there was no schedule for customers to be informed. Centlec compiled schedules on 21 January 2008 and tabled them at a meeting of the Afrikaanse Handelsinstituut as well as to a council meeting on 22 January 2008. At that time the greater Bloemfontein area had to shed 50 MW in six time slots each consisting of two hours each from 02h00 till 08h00 and again 14h00 till 20h00. To be compliant to this request Centlec had to divide to whole city, including Botshabelo, into six groups and switching was done on the 132 kV voltage level. The requirement of 50 MW was impossible since the base load at night amounted to 100 MW. To shed 50 MW therefore required almost half of the city to be switched off.

After various meetings with Eskom where this was explained to them, the allocation was lowered to 30 MW and later to 22 MW. Eskom indicated at the time that the allocation was based on the winter loads of the respective customers and allocated on a pro-rata basis of the 3500 MW required by the North Western region.

During that time Centlec shed the geysers every time Eskom requested us to do load shedding in the amount of 10 MW. Due to the fact that that amount was already tendered, it was argued that the actual load shedding should be reduced by the same amount.

In February 2008 when the situation was more stable, Eskom informed Centlec 15 minutes before the hour of the amount required. If that amount could be achieved through the geyser control, the specific group scheduled for load shedding was not switched off. The result of the latter was that the public often complained that they were scheduled for load shedding but no load shedding was done and they lost productive hours. Centlec communicated to the three community radio station almost on a daily basis to inform customers of developments as and when they occurred.

Late in February 2008 Centlec proposed to Eskom to do a pilot project to prove that more savings can be realised when load control is done. Eskom indicated that a 10% saving is required on energy.

This message was communicated extensively to all the Centlec customers. The consumption was captured on a daily basis and compared to the previous year. In order to compare a Monday to a Monday the actual dates did not correspond. The progress was good until two unexpected cold fronts arrived from 3 to 5 March as well as from 17 to 19 March and Eskom requested Centlec to revert back to the original load shedding schedule. In the analysis of the total performance for March the consumption on those days was ignored and an overall saving of 9,6 % was achieved for the month. In spite of the latter, Eskom indicated that 9,6% was not 10% and therefore forced Centlec to do load shedding again from 1 April 2008. The public response to this was very negative – instead of praise for savings rendered they were subjected to load shedding again. From a public relations perspective Eskom failed dismally on this.

It transpired later that Eskom did not believe that Centlec had the ability to really switch off 15 MW on the geyser because they could not see it on the 08h00 till 10h00 timeslot. The actual switching was done before the morning peak commences at 06h45. Eskom was invited to the Centlec control room where the actual switching capabilities were demonstrated to them. When uncontrolled switch-on is done, the geyser load amounted to 40 MW and if Centlec did not do the switching in a controlled way, it would result in a daily peak on the national grid.

A meeting was then scheduled for 18 April between Eskom, the metros and category B municipalities. At the meeting Ministers Alec Erwin (Public Enterprises), Buyelwa Sonjica (Minerals and Energy) as well as Vali Moosa (Eskom chairman) were present. Eskom gave a presentation of their experience on load shedding and indicated that munics and metros did not do enough. Centlec was also given an opportunity to present and indicated that load shedding had various negative impacts on the systems. It was indicated that energy savings were and can be realised through load control.

A meeting of the National Electricity Rescue Team (NERT) took place on 25 April 2008 where the same issue was debated. It was also indicated that the cost of load shedding to the country amounted to R1-billion an hour. Five days later an announcement was made that load shedding was suspended in the country.

The impact of load shedding

Increased maintenance

One of the critical aspects of load shedding was the fact that it increased the maintenance on switch gear as well as the fact that it exposed equipment and especially older equipment to a lot of stresses due to repeated switching.

On the 132 kV system power transformers were subjected to switching four times a day. In terms of the design specifications of these transformers in terms of IEC 60076 a power transformer is designed to handle two to three heavy faults in its life. Undue switching increases the risk of failure on equipment downstream and therefore also places the transformers at risk.

As far as the 11kV switch gear is concerned, they should be serviced after four switchings were completed. During load shedding these breakers were switched initially four times a day. If it is taken into account that there was already a maintenance summit in 2005 where it was indicated that there is a substantial backlog on maintenance, this type of switching would create time bombs on the distribution networks in the country.

On 18 April 2008 a distribution centre in Nelson Mandela Bay Metro failed and it had a major impact on electricity distribution in the area. On 22 April 2008 a 66/11 kV 20 MVA transformer of Ekurhuleni Metro exploded at the Kempton Park main supply distribution centre.

Economic impact

Within one week of load shedding in the country, various businesses indicated that they could not exist in such a climate and indicated that they would be closing their doors which would result in job losses.

As far as major retailers such as Pick and Pay were concerned, it was clear from the stock on the shelves that a major problem was caused by load shedding. Based on four hours a day and six days a week, the suppliers to Pick and Pay has lost 24 hours a week – the equivalent of three 8-hour working days per week.

Another way of calculating the cost was the GDP of the country divided by the hours of load shedding which resulted in a figure of R1-billion an hour. Therefore, if the problem was as a result of lack of coal, it was worthwhile to pay a higher premium for the coal and save the economy of the country.

The chief executive of NERSA, Smunda Mokoena, indicated on 26 August 2008 at a conference on mining and metallurgical

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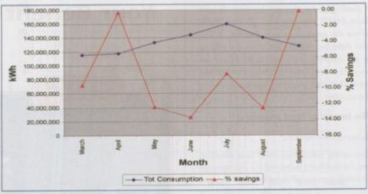

Fig. 6: Bloemfontein savings trend.

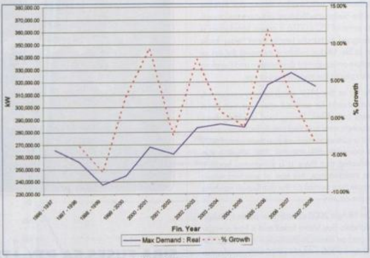

Fig. 7: Bloemfontein maximum demand.

industry that investment in the mining industry over the next five years was likely to be reduced by between R16-billion and R25-billion because of the 10% power reduction forced on mines. Mbulelo Ncetezo, NERSA's executive manager for electricity generation indicated that the cost of load shedding amounted to R50-billion based on a cost of R75/kWh of the energy required that Eskom could not supply. From 1 November 2007 to 31 January 2008 there was a shortage of 67 GWh of electricity due to load shedding.

Looking at trading figures on the JSE for the weeks ended 25 January and 1 February 2008 respectively, it can be seen that the market went into a deficit due to the fact that more shares were sold than purchased, resulting in losses of R5 330 936 and R4 147 171 respectively as a result of the uncertainty created by the electricity shortage in the country.

HR impact

During the initial stages of load shedding, Centlec was required to switch 188 11kV breakers four times a day – 30 breakers on average to be switched on and 30 breakers on average to be switched off at different places. Due to the time limit the switching could not be done by means of the SCADA system since one instruction takes 3 minutes to execute. The impact of the latter was tremendous – the normal day to day activities were totally disrupted due to the fact that staff was utilised to switch the breakers on a rotational basis. No new connections could be done, no maintenance could be done, and no repairs could be done where equipment failed.

Looking at this in a broader forum, there are numerous indications of professionals who considered emigrating and when this happened is was just so much easier to make the decision to leave the country.

International impact

The international impact of load shedding was equally horrific. Within days Standard & Poor indicated that the credit rating of Eskom was at risk. The latter was also confirmed by Moody's.

In addition to this, the position of the rand deteriorated during that time.

Alternatives to load shedding

Load control – energy and demand decrease

Centlec utilised its ripple load control system to manage both the maximum demand as well as the energy consumption.

The results obtained since March 2008 are shown in Fig. 6. The energy saving obtained through geyser control is based on the fact that a 150 litre geyser with a 2 kW element takes three hours to heat water from 20°C to 55°C and when a 3 kW element is installed in takes two hours to heat the water. Meantime the element would switch on every four hours between 11 to 15 minutes to re-heat the geyser due to radiation losses.

The control philosophy executed by Centlec is based on the fact that the geyser is heated twice a day and therefore the on-time is limited to six hours per day. The average geyser is switched on for eight hours a day if uncontrolled. A saving of 25% can therefore be obtained from the energy consumed by the geyser through this control philosophy. If these are calculated it translates to 2,18 kWh per geyser per day.

There are currently more than 1 000 000 of these relays installed in the country. If the same control mechanism is therefore followed in the country, a saving of 2,18 GWh can be obtained per day (795,7 GWh per annum). The latter is 3% of the energy saving required by Eskom per annum.

Decreased demand

The maximum demand on the system in Bloemfontein was controlled for the past 30 years. Earlier the power station formed part and parcel of the total available electricity and therefore the demand was always limited by means of geyser control. Generation by the Fort Street Power Station was done for many years only during the winter months. Originally the power station had a generation capacity of 80 MW but decreased in 2006 to 50 MW due to the failure of two generators. Generation was terminated in 2006 due to a lack of a power purchase agreement with Eskom to make it possible to generate 12 months of the year instead of only the three winter months.

Fig. 7 indicates the maximum demand of Bloemfontein since 1997. The decrease in the demand for 2008 is notable and amounted to 316 MW compared to 2007's demand of 330 – 4,24% without growth and 9,74% if annual growth of 5,5% is taken into account. The controllable load on geysers amounted to 40 MW during the winter.

In order to manage the demand a request was also made to customers to move the operation

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of swimming pools pumps to a time slot of 22h00 till 06h00. There is no reason why swimming pools pumps need to operate during the day and contribute to the morning peak. In addition to this Centlec asked customers to limit the period of operation of the pool pumps to six hours per day instead of the recommended eight hours per day, resulting in an energy saving of 25% as well as movement away from the daily peaks. Based on 5000 pools in Bloemfontein, the impact of the latter amounted to 5 MW demand saving and 300 000 kWh saved per month (3,6 GWh per annum).

Energy efficiency

A campaign was launched in Bloemfontein to issue CFLs in the lower LSM groups. A total of 420 000 lamps were installed. A follow-up project would be launched early in November to roll out CFLs in the higher LSMs in Bloemfontein. On a national basis the aim is to roll out 35 million CFLs with a saving impact of 77,19 MW and 202,86 GWh.

An active strategy was followed with regard to streetlight savings in Centlec. After various options were investigated, it was decided to convert the existing 125 W mercury vapour (MV) lamps to 50 W HPS lamps. With the existing spacing of the streetlight poles the light level would still be compliant to SANS1098. Although a lot is being said about the energy consumption of streetlights, the actual consumption in the case of the greater Bloemfontein, is that annual streetlight energy consumption amounts to 2,42% of the total annual energy purchased. An aspect often overlooked concerning street lighting is the maximum demand caused by streetlights on the system. In the case of Bloemfontein street lighting consumption accounts for 9,4 MVA of the demand on the system and by implementing the 50 W HPS lamps, the demand can be lowered by 1,4 MVA.

The conversion to replace the current 125 W MV lamps with 50 W HPS lamps would render a saving of 15% on the annual energy consumption of the streetlights. If the latter is quantified in monetary values, a nett saving of R2,1-million can be achieved. The latter is based on a policy to replace failing 125 W MV with 50 HPS lamps only and not on a group replacement basis. In addition the lamp life of the 50 HPS lamp is 20 000 hours compared to mercury vapour lamp life of 14 000 hours which implies that the streetlights would be burning in Bloemfontein during the 2010 activities and we would not be concerned about failing lamps during 2010. (The annual burning hours of streetlights amount to 4380 hours)

Energy switching

The energy consumption of the average household amounts to 1200 kWh units per month. This consumption can be divided in roughly three categories: water heating, cooking and the rest where each category is consuming one third each.

Should energy switching be implemented and cooking be converted to gas, a substantial saving can be obtained on the national grid. If it is further taken into account that cooking is done from 18h00 till 19h30, it is clear that it contributes substantially to the national peak during these peak hours. However, the influence of cooking cannot be limited to these hours only – cooking is done during the day and therefore the saving to be obtained through the implementation of gas stoves needs to be actively pursued in the DSM initiatives. Proof of the impact already exists – gas stoves were rolled-out in the Western Cape when the Koeberg generator failed in 2007.

Based on 1,5 kW per household for 2-million houses, this translates into 3 GW of load during the evening peak. If a load factor of 50% is accepted, a saving of R8,4-million per day can be obtained by Eskom based on open gas cycle turbines (OGCTs) which need not be operated due to the lower demand. The associated energy saving of the latter intervention amounts to 1 095 GWh per annum.

Implement time zones

Looking at Google Earth, the latitude of Durban is 32,5° and that of Cape Town is 17,5°. This renders a difference of 15° which translates to 59 minutes time difference when the rotation of the earth is taken into account.

This proposal goes beyond daylight savings and requires an extra hour to be added to the already existing hour difference. With a two hour difference between Durban on the east and Cape Town on the west of the country, it implies that if this principle of time zones is implemented, by the time the evening peak has passed in the Durban time zone, the peak would only start in the Cape Town time zone. The rest of the country would be between these two extremes and if the time zone differences of half an hour each are implemented, it implies that Gauteng would be in the same time zone as Buffalo City and Bloemfontein and Nelson Mandela Bay would be in the same time zone.

Implementation of time zones can have a major impact on the Eskom cost of generation because less of the expensive open gas cycle turbines would be required to augment the generation capacity of the coal fired power stations. Alternatively, depending on the set priorities of the system operator, the spare capacity created can be utilised to perform maintenance activities on the coal-fired station without a negative effect on the reserve margin.

Based on actual figures for March 2008, a model was built to simulate the impact of implementing the proposed time zones. From the model it transpired that a saving of 826 MW during the evening peak can be obtained through the implementation of this during March. The actual system demand at that time amounted to 28,263 MW. The actual winter system demand amounted to 38,200 MW and therefore an even bigger saving would be obtained during the winter months. If it is taken into account that Eskom indicated that 3000 MW saving is required, this measure can render 27,53% of that requirement without any detrimental effect to the economy.

The actual cost to implement this would be very limited. The impact on day-to-day life would be limited to the time of news broadcasts, flight departure and arrival times. Of the normal business hours from 08h00 till 17h00 a total of seven hours would be available to do business with companies in another time zone.

Non-technical losses

In an article published in the April 2008 edition of the Energize magazine, the author indicated the actual impact of non-technical losses in the country. The non-technical losses in the country can be estimated to cause an average demand increase of 1476 MW. The latter is equal to almost half of the required saving indicated by Eskom of 3000 MW.

The energy impact of 12 934 GWh represents 49,62% of the proposed saving of 26 TWh. It is therefore evident that a lot can be done by Eskom, Metros and municipalities to manage non-technical losses and address the shortage in the country. By implementing these measures the actual income would be increased and the expenses due to purchases would be lowered.

Power conservation programme

The current proposal of Eskom to implement the power conservation programme (PCP) implies that customers need to save 21% on their current consumption if it is assumed that their consumption has grown by 5,5% over the last two years. This would have a detrimental

Description	Energy (GWh)	Demand (MVA)
Swimming pools	3,6	5
CFLs	202,86	77,19
Streetlighting	331	75,5
Energy switching	1095	3000
Time zone		826
Non technical losses	12934	1476
Total	**14566**	**5460**
Eskom target	26000	3000
% Saving of target	56%	182%

Table 1: Potential energy savings.

impact on the revenue from electricity sales for all the metros and category B municipalities. To put the latter into perspective – the current surplus made by municipalities and metros amounts to between 10 and 12%. This proposed saving would have an estimated financial impact of R24,6-million on Centlec's revenue. The impact of the lower income to local government can have a disastrous effect on the financial sustainability and service delivery in the country.

In essence this scheme intends penalising paying customers for the lack of management initiatives to ensure that all customers pay for their consumption. In a project launched by Ekurhuleni Metro in Thembisa the average consumption was 1200 kWh per household and this dropped to an average consumption of 340 kWh per household. Non-paying customers are not committed to saving electricity at all since it has no positive effect on them.

In terms of the statistics released by Stats SA, in August 2008 the GWh consumption on a national basis to August 2008 compared to the previous year rendered a saving of 1,86%. The latter excludes any annual growth. If an annual growth of 5% is accepted as a norm, it implies that 6,86% was saved year-to-date on a national basis. Of the nine provinces, seven have a lower consumption and only Mpumalanga and Limpopo had higher consumptions.

Summary

Considering all the above, the possible savings of these initiatives is summarised in Table 1.

Conclusion

The paper highlights a number of facts pertaining to the load shedding implemented earlier in 2008 in South Africa:

- The decision to implement load shedding was taken without quantifying the impact on the country nor the economy.
- The fact that load shedding was implemented as a solution implies that Eskom did not have a proper action plan on the table to ensure system stability although they were aware of the worsening situation. Schedules were developed as the crisis unfolded.
- Customers need to be educated on the appropriate use of electricity.
- Alternative energy sources must be utilised to limit the reliance on electricity as the only source of energy.
- Centlec has rolled-out a number of initiatives to address both the demand as well as the energy consumption to achieve the 10% saving requested.
- There are a host of alternative programmes to be implemented in the country to increase savings and increase the reserve margin on the supply system without any negative impacts on the economy. These should be the first priority for implementation and should be supported by national government to ensure compliance since they are based on sound and accountable principles.
- Energy and demand savings are required to increase the safety margin on the supply system and ensure stability.
- The skills shortage in the country needs to be acknowledged and engineers and technical staff need to be valued and remunerated higher to ensure they are retained in the country.
- The implementation of the PCP programme is morally wrong because it targets paying customers and ignores the responsibility of the respective distributors to manage their own customers and ensure payment for electricity consumed.
- A concerted effort is required to manage non-technical losses by all distributors to a value of less than 1% to obtain savings from all customers.

Disclaimer

The views expressed in this paper are those of the author and are not necessarily those of Centlec.

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National Electrification Advisory Committee [NEAC]

This report covers the period since the AMEU Convention in Durban in October 2007

The AMEU is represented on the NEAC by Peter Fowles while Sandile Maphumulo represents SALGA. An Integrated National Electrification Planning [INEP] Business Planning Unit [BPU] of the DME provides the secretariat and project management roles for the NEAC.

Municipal performance in the 2007/08 programme: NEF

The total municipal allocation for the 2007/08 financial year was R467-million of which R60-million was allocated to bulk infrastructure projects. Only R134-million [29%] of this funding had been transferred as at September 2007 with 8666 connections completed out of a target of 66 756 to that date.

At the end of January 2008, municipalities had received 56% of this R467-million allocation although only 41% [R196,3-million] had been spent. This had translated into 16 758 connections reported completed representing 25% of the anticipated number of of 66 756.

INEP officials suggested that allocations will be withheld from those who do not perform and ultimately taken away during the November re-gazetting process.

Municipal 2008/09 budget allocations

The total municipal allocation for the 2008/09 financial year is R595-million, of which R249-million has been allocated to bulk infrastructure projects and R136-million to 2010 World Cup Host Cities. The allocation is to achieve 46 737 new connections. Applications from municipalities totalled R2-billion of which R1,12-billion was applications for bulk infrastructure projects.

At the NEAC Macro Control meeting held on 17 September 2008, it was reported that only R30-million of the allocation of approximately R595-million for 2008/09 [available from April 2008] had been transferred to municipalities to date.

It was suggested during the NEAC meeting that allocations to a number of municipalities may be withdrawn during the government re-gazetting process that will take place during October 2008. AMEU President, Sandile Maphumulo, therefore convened a meeting between DME Regional Energisation Managers [REMs] and the officials responsible for electrification projects in ten of the largest municipalities to discuss performance. Among the resolutions emanating from the meeting were requests to:

- DME to attempt to avoid removing or reducing allocations of electrification funding.
- Municipalities having difficulty in meeting the business plan submitted as part of their application to the NEF for funding, to contact their REM as soon as possible to discuss the matter and request, if possible, permission to transfer the funding to another project.
- Share best practice from performing municipalities.
- DME to expedite the release of funds made available through the re-gazetting process.

Policy documents

The NEAC meeting of 27 February 2008 resolved that the connection fees applicable from 1 April 2008 would be revised. The main effect of this decision is that the INEP expects that no connection fee is to be charged for electrification connections rated at 20A or less for which subsidies are provided from the NEF.

World Cup 2010 electrical infrastructure funding

INEP have been given responsibility for assessing applications from Host City municipalities for funding. Applications for funding from the nine host cities submitted in December 2006 amounted to approximately R2-billion but only R67-million was provided in the 2007/08 financial year [R7,5-million per city] and R136-million in the 2008/09 financial year.

Peter Fowles, AMEU representative

Electricity Suppliers Liaison Committee [ESLC]

This report covers the period since the AMEU Convention in Durban in October 2007.

The ESCL has been chaired by Roy Wienand, eThekwini Electricity, since 1994 and the ten largest municipal distributors are eligible to nominate representatives to serve on the committee. These as well as a number of other municipalities, facilitate and support the involvement by a considerable number of their technical staff on the NRS Workgroups.

The Committee has met on four occasions since the 2007 AMEU Convention. Following the resignation of Michael Rhode, the AMEU Technical Committee resolved to ask Kevin Grunewald of George Municipality to be its representative on the ESLC to look after the interests of the 'smaller' municipalities. Unfortunately, Mr Grunewald has not yet been available to attend an ESLC meeting. Peter Fowles also serves on the ESLC to coordinate the technical and administrative activities required by the AMEU.

A Project Management Agency [PMA] funded by Eskom provides the secretariat and project management roles for the ESLC. Final NRS specifications continue to be approved by the ESLC and published by Standards South Africa.

Matters of interest arising out of the ESLC activities are regularly reported in the AMEU e-Bulletin and copies of the PMA Quarterly Report are posted on the AMEU website for the information of interested readers.

Significant points of interest arising during the course of the year are:

- Guidelines for the connection of PV systems to distributor networks: A need was identified for the establishment of guidelines for the use of grid connected PV. Initially a workgroup under Eskom Research was established and included representatives from the AMEU as well as technical specialists from Eskom, equipment suppliers and consultants. The ESLC have agreed to establish a work group to produce a national standard for the interconnection of embedded generation which will include the requirements of PV systems as well as the AMEU guidelines for portable generation.
- Asset Management Project: The NRS 093 workgroup, has finalised the draft for Part 1 (Minimum requirements for asset management in the EDI SA) which has been sent to an accounting practitioner for checking as well as to Standards South Africa for final editing.
- Metering Training Courses: Eskom again extended an invitation to AMEU members to attend one of their 'General Metering Courses' covering issues relating to NRS057
- NRS 049: Advanced Metering Infrastructure (AMI) For Residential And Commercial Customers: The ESLC responded to an anticipated requirement of the PCP to have the industry fast track the roll out of domestic time of use (TOU) metering by establishing an NRS workgroup to develop a standard for 'smart metering'. The standard was approved in August 2008 and is now available for use.
- Load shedding: Due to the widespread concern that the incidence of load shedding is having a negative impact on certain electrical network equipment, the ESLC established a workgroup to assess this impact.
- DSM Strategy Overview: A report on the Eskom DSM Strategy to the ESLC highlighted the fact that that the principles have become more output and measurement-focussed than previously. It is now the intention to
  - Focus on energy efficiency rather than load management
  - Focus on equity of DSM programs across all sectors
  - Focus on measurable and sustainable savings that add value to the national system and the recovery process
  - Encourage the promotion of Innovation in DSM

ESLC meetings for the remainder of 2008 are as follows: 20 November 2008

Peter Fowles, AMEU representative

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AMEU Education and Training Committee

This report covers the activities of the AMEU Education and Training Committee for the period since the AMEU Convention in Durban in October 2007.

This committee deals with issues related to technical training to meet the needs of municipal electricity distributors. Currently chaired by Hannes Roos of Ekurhuleni Metro it includes, in addition to members of the Executive Council, representatives from Eskom, EDI Holdings and municipal HR and training experts.

Three meetings of the committee here held since October 2007. The major items arising from discussion at these meetings are:

- *AMEU/Eskom Training Standardisation:* Due to the possible restructuring of the EDI, the AMEU and Eskom have been working toward standardizing training material for distribution related functions. After initially undertaking to provide an amount of R2-million to Tshwane Metro's Training Material Development Project Team for the development of training materials [NQF 2 – 4], the ESETA decided to request proposals in a tender process. As at the 25 June 2008 meeting, no further details were available on the result of this tender.
- *Survey on Electrical Engineering Skills Shortage:* The AMEU will support SALGA in arranging a stakeholder workshop on the skills shortages affecting municipalities. Little progress has been made on this issue. It also appears that this issue is now to be addressed by a new structure to be established by EDI Holdings.
- *Standards Generating Body [SGB] Representation:* The Committee approved the nomination of four senior training managers as AMEU representatives on the SGB for Electrical Engineering.
- *Master Artisan Programme:* Eskom, in partnership with the Department of Labour [Indlela] and the Tshwane University of Technology, invited the AMEU to nominate three representatives to serve on a steering committee tasked with the development of a Master Artisan Programme [Certification]. It was agreed that nominations of senior electricians to take part in the first course would be employed by Tshwane, Ekurhuleni and City Power. Training material for the programme had to be developed.
- *National Training and Development Forum [NTDF]:* EDI Holdings announced its intention to establish a National Training and Development Forum [NTDF]. Terms of reference were distributed for comment. It was proposed that the current AMEU/Eskom Technical Training Committee as well as all other training forums involving the AMEU/Eskom and EDIH should be incorporated into the NTDF. EDI Holdings also stated that the LGSETA and ESETAs were interested in a cooperation agreement to assist in the allocation of funding that had remained unspent EDI Holdings was of the view that the NTDF was the body that would be able to address the issues blocking the roll-out of training as all the relevant stakeholders would be involved. The establishment of the NTDF had been delayed due to the need to address many other issues in the EDI environment. EDI Holdings claimed that the NTDF would shortly be addressing the key issues of a strategy for training and retention of skills in the electricity distribution industry.
- *MERSETA Qualifications:* The Committee noted that increasing numbers of "electricians" are coming into the industry via an eight-week training course that does not cover enough subject matter to meet the needs of skilled municipal distribution electricians. Utilities are free to employ such persons and then train them to their required standards in order to ensure that operational safety is not compromised. AMEU members were advised that applicants for electrician posts with MERSETA qualifications should be required to undertake an 'in-house' trade test before an appointment is made. It was reported that at a Department of Labour [DOL] workshop on the revised Electrical Installation Regulations [EIR] held on 13 June 2008, the issue of MERSETA qualifications was raised. DOL stated that:
  - It has no record of the recipients of MERSETA certificates being trained and thus does not regard them as being 'competent persons'; and
  - The ESETA have been tasked with assessing the accreditation of these qualifications.

  It is also understood that the ESETA has commenced a pilot project [in the Ekurhuleni area] to assess the learnership and apprentice routes to becoming a qualified artisan. DOL and the ESETA be approached to provide guidance on:

  - How municipalities should deal with applications from prospective applicants in receipt of MERSETA [and other non-ESETA accredited training courses] qualifications; and
  - How municipalities should deal with current employees who may be in possession of MERSETA qualifications and who are requesting to be recognised as qualified artisans.

Hannes Roos, chairman

South African Revenue Protection Association [SARPA]

This report covers the activities of SARPA for the period since the AMEU Convention in Durban in October 2008.

The primary mission of SARPA is to promote the exchange of information in the field of protecting the income and assets of utilities against pilfering, misallocation and misappropriation. Its is made up of utilities involved in the supply of electricity, water, communication and related services as well as contractors, equipment manufacturers and consultants.

Three meetings of the SARPA Executive Committee have been held since October 2007, and its 12th Annual Revenue Protection Convention took place on 17 and 18 July 2008. The current President is Dirk Byker from Tshwane Metro Electricity. Highlights from these meetings are:

- *Bushveld Branch:* a new Branch of SARPA has been established to serve the north eastern portion of South Africa
- *Technical consultant:* The Executive Council of SARPA resolved to employ Rens Bindeman to act as the technical consultant of SARPA and to provide training and lobby services for SARPA on contract basis.

The 2008 Annual Convention was held at the CSIR Convention Centre, Tshwane, and well attended with approximately 240 registered delegates. The paper reporting on the new strategy currently being implemented by the Non-Ferrous Theft Combating Committee [NFTCC] was of particular interest – This is a "Turnaround strategy in the fight against non-ferrous crime" by Adv. Simi Pillay-van Graan, Business Against Crime:

Adv. Pillay-van Graan advised that while the NFTCC had been treating only the symptoms of the problem, national government was now taking a leadership role. The deputy minister for safety and security would become chairperson of a national forum [steering committee] which would now also include key stakeholders such as the NPA, Asset Forfeiture Unit, SARS, SAPS and many others.

The national NFTCC will be transformed from a reporting forum to a proactive operational forum and will be chaired by the SAPS Commissioner for Organised Crime. Non-ferrous theft has now been deemed a 'priority crime' with the relevant instruction issued to all police personnel.

In addition, the long awaited revision of the 2nd Hand Goods Act [1955] has passed through the National Assembly and was due to be presented to the National Council of Provinces [NCOP] on 26 August 2008.

If implemented effectively, this strategy will be of significant assistance to our industry

All the papers and presentations from the convention have been posted to the SARPA website library at www.sarpa.co.za/events/ under Convention 2008.

Peter Fowles, AMEU representative

Progress report on Standards South Africa committees and NRS workgroups

AMEU nominated representatives serve on a number of SABS Standards Division Technical Committees and Electricity Suppliers Liaison Committee [ESLC] working groups convened to produce National Rationalised Specifications [NRS].

A number of the committees have an IEC label as these are known as "liaison committees" of the SABS Standards Division committees.

The IEC liaison committee is either a P-member (participating) or an O-member (observer) of the international committee (this is decided by the SABS Standards Division TC/SC).

The primary goal of the ESLC remains the bringing together of technical experts from Eskom, municipal electricity distributors and other interested parties [e.g. NERSA, SABS] into workgroups to create national [NRS] equipment and other technical specifications.

Reports are available from:

- IEC TC 13, (WG11; WG13);
- IEC TC 57;
- IEC TC 58;
- SABS TC 64;
- SABS TC 67F;

and from NRS groups.

Peter Fowles, AMEU strategic adviser

PIESA Report on Activities 2008

The Power Institute for East and Southern Africa (PIESA) was established on 28 February 1998 to facilitate and coordinate the sharing of information and technology. This work is achieved largely by the sharing of expertise between members. PIESA aims to be the catalyst for sustainable regional technological co-operation in expanding the electricity distribution industry for regional growth and development. Once again, we can report on a very successful year.

Five technical working groups form the core of the PIESA: Electrification, Environmental Management, Non-technical Loss Reduction, Power System Analysis, and Standardisation, each under the leadership of a convenor. The working groups are encouraged to meet as often as required between board meetings, and it is envisaged that several of the work groups will meet in Maseru in February 2009. All working groups had successful meetings during the allocated days, and participated in technical visits arranged by the Eskom hosts on the third day.

The relationship between the AMEU and PIESA has been working very well, and a request has been submitted to the AMEU representative for the PIESA to participate on the technical committee of the AMEU to reinforce this relationship and share areas of common interest.

AMEU Tariffs Committee

The committee met three times in an unusual year. The year started off with presentations from Eskom on its proposed tariff restructuring. NERSA however announced in October 2008 that Eskom's application for tariff restructuring had been approved and will thus probably be implemented with effect from 2009.

After huge public debate and many public meetings NERSA announced the approval of an additional 13,3% on top of the already approved 14,2% resulting in an average 27,5% increase for Eskom direct customers. As the increase was effective from 1 July 2008, Eskom's non-municipal customers experienced an average increase of 20% [they had already been paying the 14,2% increase since 1 July] while the figure for AMEU members was a 35,9% bulk increase. The already long suffering electricity customers will have to dig deep into already constrained budgets.

While we all await NERSA's finalisation of the Renewable Energy Feed-in Tariff (REFIT), some AMEU members have continued to support private projects aimed at renewable energy generation and the wheeling of this energy to willing customers.

The road ahead looks just as challenging. Proposed regulations to the Electricity Regulation Act will see AMEU members further stretched when implementing the Power Conservation Programme [PCP] as part of Government's proposed Energy Conservation Scheme [ECS].

The government's proposed 2c per kWh environmental levy ["carbon tax"] on generation, announced in the 2008 budget, is close to becoming a reality although National Treasury and NERSA have not yet decided how this is to be passed through to the end customer.

Roy Wienand, chairman, AMEU Tariffs Committee

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City of Matlosana Municipality	Wynand Viljoen	P O Box 99, Klerksdorp, 2570	(018) 462-9851	(018) 464-1221
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1983 & 1988	JK von Ahlften	Springs
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1953-1954	JC Fraser	Johannesburg
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1962-1963	JC Downey	Springs
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1981-1983	W Barnard	Johannesburg
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1985-1987	AHL Fortman	Boksburg
1987-1989	FLU Daniel	Cape Town
1989-1991	CE Adams	Port Elizabeth
1991-1993	HR Whithead	Durban
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1999-2001	AJ van der Merwe	Bloemfontein
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Jan Venter	Cape Town
14th Technical Meeting - August 1992	
William Lashley	GEC
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Protective functions	**IEC**
3-phase overcurrent, Low set (DMT, IDMT)	I>
3-phase overcurrent, High set (Inst. Or DMT)	I>>
Earth-fault, Low set (DMT, IDMT)	I_0>
Earth-fault, High set (Inst. Or DMT)	I_0>>
3-phase Transformer Inrush detector	$3I_{2f}$>

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Time:	Exhibition viewing: 07h30 to 19h00; Conference: 08h30 to 17h00
Venue:	Gallagher Estates, Midrand, Gauteng, South Africa

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