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2007

Special **AMEU** Proceedings Edition

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SPECIAL ISSUE

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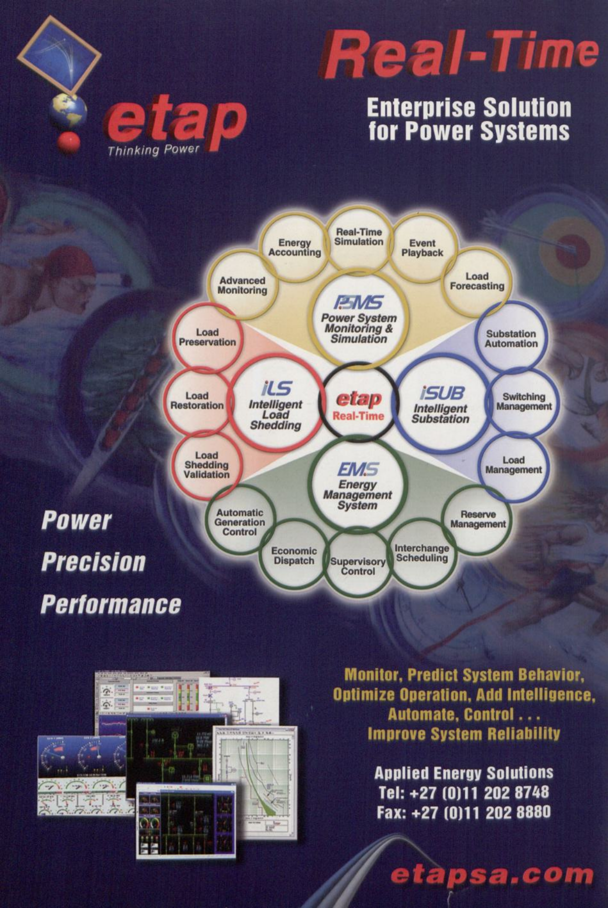
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Information from Aberdare Cables

Aberdare Cables, a member of the Powertech Group, is a leading African manufacturer of cables with five manufacturing sites, in three provinces of South Africa, and offshore operations in Mozambique, Portugal and Spain.

The company's customer base includes power supply authorities, railway and transport organisations, municipalities, and companies in industries such as petrochemical, mining, wholesale, industrial, construction and domestic building. The company manufactures and sells a wide range of state of the art products with customer specific adaptation, design capabilities and full technical back-up service. Aberdare Cables prides its self on its ability to identify and satisfy customer needs through development of innovative products; unique, cost effective cable solutions for a wide range of industries.

Aberdare Cables pursues ongoing technology development programmes, and through active association with its local and overseas affiliates, continues to remain at the forefront of technology. The company has been recognised internationally as a pioneer in cable advancements. Aberdare serves on a number of SABS and International Electro Technical Commission (IEC) cable working groups.

Aberdare Cables is a fore runner in the industry with regard to quality. The manufacturing, quality assurance, testing and research resources of Aberdare are of a world-class standard. In fact, the company was one of the first companies in South Africa to be awarded the South African Bureau of Standards (SABS) Quality Assurance Certification, and has been ISO 9001 compliant for many years. Aberdare Cables is UL listed and has Basec QA accreditation.

Aberdare has embraced the empowerment concept. Today, 30% of the company is owned by Izingwe Consortium and the company has assisted in the development of a number of black enterprises, such as Drumco, the company that makes Aberdare Cable Drums. At Aberdare, education, training and development are crucial tools to build empowered and dedicated employees. In this regard the company actively promotes and follows a number of education programmes, including adult education, apprentices, trainees, learnerships and formal education assistance.

Aberdare Cables has always been an active supporter and pillar of strength for the communities in which it operates. The company is championing a number of social investment initiatives across our country. The biggest of these investments has been the continuous sponsorship of Sinithemba home for street children in Port Elizabeth. An on-going supply of equipment necessary to creates a sense of self sufficiency and pride at the Abercare Centre for mentally and physically disabled people in Pietermaritzburg. An investment of R1-million in computer workstations for a new computer laboratory at the Nelson Mandela Metropolitan University allows students from disadvantaged backgrounds access to vital computer amenities. Half a million Rand investment is building an administration block at the Charles Duna School in New Brighton. A continuous provision of equipment and materials enables Sunfield Homes, in Johannesburg, to assemble Moon Lights and cable end caps, which the home sells.

As a proudly South African company, Aberdare participated actively in the development of the ICT charter and the draft DTI BBBEE codes. Aberdare will continue to adopt a proactive approach to effect the transformation that the codes specify and to lead the cable industry in this regard.

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Welcome by outgoing AMEU president

Vally Padayachee, City Power, outgoing AMEU president

Its gives me great pleasure on behalf of the AMEU to formally welcome you to this 60th AMEU Convention. The AMEU as an organisation is also over 90 years old and therefore steeped in history. It's also obvious I guess that an organisation with such a long history has been through various and different eras and challenges. What is also obvious is that the AMEU has survived challenges long before the apartheid era, survived challenges during the apartheid era and now it is facing huge challenges in the post apartheid democratic era since 1994. If you examine the mandate or the role of the AMEU very closely, I am sure you will agree that the AMEU, through its various activities, interventions, etc., has played a significant role in its long history in assisting the relevant stakeholders in keeping the lights burning. The challenge of keeping the lights burning, which became very clear last week when we had load shedding, is now becoming onerous. To address this particular challenge within the context of adequacy and security of power supply in the country is, I believe, going to be the biggest test for the AMEU as an organization – depending on the strategic path we choose to embark on going forward it could ensure whether we survive as an organisation. It is therefore within this context that we've attempted to put together as an AMEU a programme for this convention that will hopefully provide more information, give some strategic direction and elicit open, fair and healthy debate amongst all of you for the next three days. We've also in choosing the papers tried to cater as far as possible for all delegates. We've also been fortunate in the last two years to have had the luxury to turn away papers because we were over subscribed.

This convention is also an opportunity for all of you to network, share business cards, etc. However, it must not be all work and no play – I'd like all of you to have fun. Yesterday most of you did take part in the various sporting activities. Durban is a beautiful coastal city and like all coastal cities throughout the world it does bring added advantages. As the AMEU, we've also ensured that the spouses and partners of our delegates are also kept "enjoyably busy".

Sandile Maphamulo, the incoming AMEU president, and I have a bet – he has indicated to me that eThekwini wants to beat Johannesburg's very successful convention that was held last year at Gallagher Estate.

Lets see how this goes! Δ

Inaugural speech by incoming AMEU president

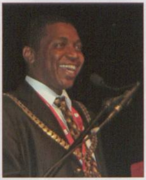
I would like to thank my council, eThekwini Municipality for the support they have given me from the time I was elected deputy president elect till now. It is important to note that eThekwini Council is the major sponsor of this whole event. Their sponsorship was not only limited to voting a sizeable budget for this event, but also came in the form of unqualified support for everything that approached them with. I thank my mayor, Ubaba uXimba, for having the confidence he has in me, by letting me loose knowing that I would never easily leave his organisation, this is what I know exposed me widely, and in the process, colleagues in the industry began to grow confidence in me leading to my cooption in the EMEU executive structures. I would like to thank our city manager, Dr. Suttcliffe, for his visionary leadership of this beautiful city, Krish Kumar for the financial support, my boss Derek for understanding each time I have to attend all the engagements for the AMEU, my ex boss, Howard (there I did it), never called him Howard before, always "Mr. Whitehead". I am sure without his careful guidance I may not have been standing here, and more importantly, this convention would be hosted somewhere else. In his absence, I thank him. I thank the executive of eThekwini Electricity and staff for their support and keeping the ship afloat all the time. My sincere thanks go to Rosemary for single handedly arranging this AMEU convention from scratch with guidance from the AMEU Secretariate, and particularly Gillian le Cordeur. How can I forget the Affiliates. They are an integral part of this association. Without them, we would be one legged. It is for this reason that I will urge us all to visit their exhibition stands at every opportunity you get. I thank them for their continued participation and sponsorship of these conventions.

All this would have fallen on the desert soil if I did not have unqualified support from my beautiful wife, Mrs. Maphumulo. Her support gives me the courage of the lion and the stamina of a camel to pull through, even in difficult times.

You can realise that this presidency is actually not mine, but for the host of people that have contributed to me having this chain around my neck.

It gives me great pleasure, and at the same time, humility to stand here before you at this Convention, ready to tackle the challenges of leading this association, which has survived for more than 90 years.

One may wonder why the theme, "Phezu Komkhono" (Get on and do it). The country is inundated with many flagship projects. The Gautrain, the EDI restructuring, 2010 FIFA World Cup hosting, universal access by 2012 (coinciding with the ruling party's centenary celebration), and building of new generation capacity, just to name a few. These projects have an unusual relationship. They are competing, yet



Sandile Maphumulo, eThekwini Electricity incoming AMEU president.

very complementary in nature. They compete for scarce resources, most notable being skilled resources. They are complementary in that each aims at infrastructure improvement, especially the latter three.

As if this was not enough, the NERSA audit of the distribution network painted a gloom and doom picture. As Greg Tosen articulated in his chairman's report at the IERE/PIESA conference some three weeks ago, "the power outages throughout the country brought into sharp focus the vulnerability of our power systems, and put unprecedented pressure on skilled people to implement and operate new investments to meet the high demand for electricity". Just last week, we all witnessed wide ranging controlled power outages to try and balance supply and demand. As a result of this load shedding management, me and my electricity staff have been dubbed idiots, and as for me and Vijay, brainless, by one of the so called businessmen, Mr. Rorke. As professionals, we must just be resilient and do what we do best, and ignore those that try to derail us from doing what is best for the country.

All these challenges call for us to do business differently. We must address these challenges as a united front. Why should we compete with each other when we can cooperate? There is no use of us fighting over the scarce skills available in the industry. We need to find creative ways of resource utilisation. What stops me, in Durban, from requesting Eskom to assist me in areas where I lack skills, and then steal the same skills from them? Their only alternative will be to steal back from me, and in the process increase our cost of doing business. We have to work together in the building of these skills. We must optimise our training resources, both from government and the private sector. We are all in this together. The example of the cooperation in the building of the skills base is the envisaged cooperation between Eskom and the AMEU to train master electricians. Naude van Rensberg will be presenting a paper covering this as well.

The other issue that needs addressing is AMEU involvement within the ESI. Over the years AMEU has played a crucial part facilitating information exchange among the industry players, and assisting with guidance for under resourced members. We have contributed in various ways in restructuring issues. We pride ourselves on being proactive in matters of national importance. Together with Eskom, we have formed a 2010 ESI Forum bringing together all role players ensuring that preparation for the hosting of the Soccer World Cup is on track for all host cities, and for cities hoping to provide base camp facilities. The committee has been instrumental in liaising with both DME and National Treasury for 2010 infrastructure related funding, and at the same time researching FIFA technical requirements for electricity supplies, both within and outside the match venues. Clinton and Peter will tell us more on that in their joint paper.

Of particular importance is the relationship between the AMEU and SALGA. While of late we have had some associations springing up claiming to be SALGA technical advisers, the AMEU has a lot to show and to prove that it holds this position. I love competition, and I love challenges. At the end of the day it is what we do and how we manage our relationship with SALGA that will separate us from the rest. We treasure our relationship with SALGA. Our constitution endorses this, as the membership of the AMEU comprises the municipalities represented by both the heads of electricity and councillor members. I can assure all councillors present that the AMEU will endeavour to serve their interests, and I request councillors to work with us as well. We are different sides of the same coin. Whether we like it or not, we cannot be separated. Councils are our bosses.

As for the DME, I would also like to forge close relationships with the Department. There are many areas of cooperation that we can have, including training for increased ESI skills in the country. We can provide practical training for interns that DME may want to engage. On this, we have already started discussions with Martin and will extend them to Ompie as well.

Ladies and gentlemen, before I stand between you and the rest of the proceedings, I have to stop here. Angingegeqe amagula sengathi kuyemukwa.

Cllr. Visvin Reddy, thank you for your opening prayer. Cllr. Logie Naidoo (deputy mayor of eThekwini Municipality), thank you for your kindness and making yourself available to open this convention and for welcoming us in your warm city (the city that never sleeps). Kevin Nassiep, thank your for an electrifying keynote address.

To all the delegates, we have been given the green light for this convention and let it begin!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Report of the AMEU general secretary for the period 2005 – 2007

by Jean Venter, Van der Walt & Co., AMEU general secretary

The AMEU, now in its 92nd year of existence, continues to play a strategic role in the electricity distribution industry in particular and in the energy sector in general.

During the period under review, the AMEU executive council met on four occasions, while the eight council committees met on six occasions each.

I can report that member attendance at executive council meetings and committee meetings is exceptionally good. The open committee policy that the council has now pursued for some years, has resulted in various stakeholder organisations such as EDI Holdings, Eskom and NERSA being regular participants in many of the AMEU committee meetings. This level of outreach and open participation has created strong bonds for the AMEU with these stakeholders.

The council strengthened the capacity of the association around two years ago by appointing Peter Fowles, a past president and honorary member of the AMEU, to the position of "strategic advisor". This position combined the roles of technical secretary previously held by Jules von Ahlften and Al Fortmann, with new needs to increase AMEU representation on stakeholder committees, and the need for AMEU to provide inputs into many new legislative and industry processes. In addition, Peter has also acted as a consultant to smaller municipalities on behalf of the AMEU, to advise on industry restructuring processes. Peter has also played a key role in creating an information bridge between the AMEU branches and national activities of the AMEU and the industry in general.

The AMEU Affiliates remain one of the backbones of the AMEU, and their participation now under the leadership of Bob Wallace has been vital to the success of the organisation. During the period under review, the then chairman of the Affiliates committee, Trevor van Niekerk, passed away, and an interim election was held to elect a new chairman for the committee.

Financially, the association is in a strong position. Unqualified financial audit reports were issued for both 2005 and for the 2006 financial years. Financial surpluses were generated in both years, after taking into account planned transfers from historical reserves, aimed at reducing the asset base to more realistic levels.

Max Clarke continued to edit the AMEU News providing excellent industry reporting to our membership. The monthly electronic bulletin, now edited by Nadia van Niekerk at the AMEU Secretariat, is distributed on a monthly basis to members. In this regard we need to acknowledge the vital role that Peter Fowles has in producing strategic content for the electronic bulletin without which it would not be as valuable a communication medium to the AMEU.

On a branch level some concern is emerging on the level of member participation in branch meetings, and a meeting of the finance committee has been scheduled to workshop this matter and to provide recommendations on what can be done to broaden branch participation.

During 2006, the Engineering Council of South Africa (ECSA) recognised the AMEU as a "Voluntary Association". Our members, many who are registered with ECSA, can now earn CPD points by attending AMEU conventions, branch events, and committee meetings.

It is my pleasure to submit this report on the activities of the AMEU over the past two years.

Update on EDI restructuring

The CEO of EDI Holdings addressed the 60th Convention of the Association of Municipal Electricity Undertakings (AMEU)

The chief executive officer of EDI Holdings, Phindile Nzimande, addressed delegates on the opening day of the 60th Convention of the Association of Municipal Electricity Undertakings (AMEU), held at the International Convention Centre in Durban on 15 - 17 October 2007.

The convention, which was held under theme: Phezu Komkhono, "Get on with it", was attended by a variety of key stakeholders from the electricity industry such as electrical engineers in the distribution industry, municipal managers, municipal treasurers, manufacturers of electricity distribution equipment as well as representatives from electricity utilities from the African continent, amongst others.

Nzimande used this opportunity to inform delegates about the cabinet decision of 25 October 2006 relating to the EDI restructuring process, in terms of which six wall-to-wall Regional electricity distributors (REDs) must be created as public entities regulated by the National Energy Regulator of South Africa (NERSA).

Phindile Nzimande, CEO of EDI Holdings

She also used this occasion to bring delegates up to speed with developments in the restructuring process for the electricity distribution industry, especially progress made since the cabinet decision.

Over and above the cabinet decision of 25 October 2006, the other topics that were covered in the presentation by Nzimande are the following:

- The current structure of the electricity supply industry
- Key challenges facing the electricity distribution industry
- The objectives for EDI restructuring
- The RED ONE experience
- Implementation challenges
- Key considerations and implementation enablers
- The RED establishment roadmap
- "Deal" formulation

The chief executive officer was accompanied to the convention by executives and senior management of EDI Holdings, who participated actively in deliberations and activities for the duration of the convention. EDI Holdings also mounted an exhibition stand at the convention which sought to amplify Nzimande's message by distributing information and promotional material about EDI Holdings and the restructuring process.

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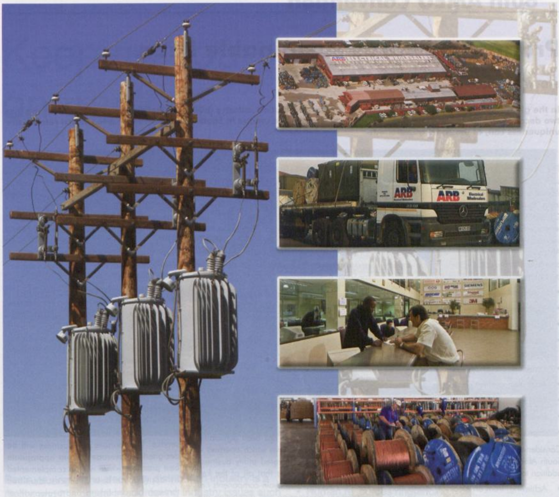

Progress towards sustainable REDs

by Dr. W J de Beer, EDI Holdings

In the global context, restructuring and the electricity distribution industry (EDI) have become synonymous over the last two decades. While we hear the claim many times that we are unique in South Africa with respect to the EDI reform, the uniqueness can, at times, be questioned.

The restructuring experience of countries such as the United Kingdom, Australia, New Zealand, United States, Latin America, Spain, India, Brazil, Argentina, Poland, Namibia and Germany amongst many others could be leveraged and effectively utilised to ensure the successful transformation of the EDI in South Africa. In researching EDI reform in other countries it is clear that the reform is informed by a number of drivers, intealia:

- Customer service expectations
- Customer choice
- Socio economic drivers
- Increasing access to affordable energy sources
- Economic growth requirements
- Asset management challenges
- Efficiency improvement requirements
- Investment / funding requirements
- Improved regulation

Considering the challenges facing the EDI in South Africa one could add the following in addition to the above points:

- Achieving, from an electricity distribution perspective, universal access for all households by 2012
- Maintaining the low cost of electricity
- Address the sustainability of the EDI
- Create sustainable employment opportunities

From the above it is therefore clear that many of the global EDI reform drivers are equally applicable in the South African context. However, when considering the global restructuring drivers, challenges, progress and restructuring successes, two significant differences are evident in comparing the situation in South Africa with most of the other countries around the globe; namely that in the case of South Africa the EDI restructuring is taking place in a voluntary environment and that there are no privatisation motives. Having the enabling legislation in place to facilitate this process contributes significantly to clarity, momentum and the reduction of extensive discussions which yield little, if any, benefits. Furthermore in the case of South Africa the focus is not on privatisation or centralisation since the business model is clear that the national government, local government and Eskom will be the shareholders of the future REDs. It therefore implies that the assets of the 187 municipalities licensed to distribute electricity and the assets of Eskom Distribution will be merged into six independent companies, operating under the Public Finance Management Act (PFMA). Considering the current approach to the restructuring in South Africa, recognition must be given to the extensive opportunities created for all stakeholders to participate in the process and to influence the business model developed for South Africa.

It is important to note that while the generation and transmission components of the electricity supply industry (ESI) are critical from a supply side perspective, it is the distribution component of the value chain which determines the ability to deliver quality services from an electricity perspective to end customers. Without a sound distribution system it would be impossible to realise realistic economic growth in line with government objectives in this regard.

Business model

The ESI in South Africa has been dominated for many years by Eskom which operates a classic vertically integrated utility business operation. This implies that all of the key electricity supply value chain components i.e. generation; transmission and distribution are vested in the same business. Municipalities on the other hand have predominantly played a role in the distribution environment with a limited number of municipalities also having a limited generation capability. None of the municipalities in South Africa with a generation capability has sufficient generation capacity to meet the electricity demand within their own area of jurisdiction.

The above situation provides Eskom with a monopoly position within the South African electricity market context. The vertically integrated business model is widely regarded as a less than optimal approach since it offers amongst others the option of hiding inefficiencies, working against a level industry playing field and restricting real market developments. However Eskom must be commended for their contribution to the ESI in South Africa since 1922. For an effective industry it is essential to have economies of scale, the ability to generate revenue at a rate affordable to the customers and to meet the capital and operating challenges while creating shareholder value. There is therefore a clear relationship between a sustainable RED, revenue, capital expenditure, continuous efficiency/business improvement and value creation. While a model leaning towards centralisation might bring financial savings, the REDs need to be customer-focused and close to the customer from a service delivery perspective and therefore the model selected for South Africa is a decentralised model. Local government has the responsibility to ensure delivery of electricity to the customers within the municipal area of jurisdiction and the proposed decentralised RED model will be well positioned to ensure effective service delivery. The relationship between the relevant municipality and the relevant RED will be regulated through a Service Delivery Agreement (SDA) as contemplated in the Municipal Systems Act 2000 Section 81. The business model is further developed along the lines of appropriate best practices and will be an integrated value chain-driven organisation with a distinct "wires" focus and a distinct "retail" focus supported by a common corporate and support service. Furthermore the business will be designed to leverage current appropriate best practices which will be complemented by appropriate best practices identified through benchmarking and evaluation of international best performing utilities.

Extensive EDI modelling and evaluations have indicated that there are significant efficiency improvement opportunities to be gained outside the payroll area. These opportunities include the refinancing of the current industry debt, managing of debtors, addressing the billing challenges, addressing technical and non-technical energy losses and leveraging shared services within the industry and legacy parent organisations. Leveraging on the learnings derived from power failures in other countries, the distribution grid between REDs will be operated in an integrated manner while there will be a strong drive towards overall network automation, automatic meter reading, automatic metering information management and integrated asset management.

In addition to the impact on reliability improvement such an approach is regarded as essential to ensure effective load management, to protect the distribution grid integrity and to enhance the customer interface opportunities. The RED will buy energy based on the wholesale electricity pricing system (WEPS) principles and all customers served off the wires under the control of the relevant RED will contribute to the applicable wires charges.

Keeping you on track.*

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RED creation: serving the interests of key industry participants

Current asset owners

In line with existing legislation applicable to municipalities, in the restructured industry, municipalities will remain the service authority while the REDs will be the service providers. While it is recognised that there are current pockets of excellence in the EDI and that revenue is generated, when assessed holistically, the industry is not sustainable in its current format. The industry is marked by significant under-investment in asset management, lack of infrastructure investment to support future growth, an increase in power failures, inconsistent customer service standards and inefficient and unsustainable business practices are evident. While some of the current asset owners attribute blame to the uncertainty created through the restructuring process as the reason for not investing in their electricity distribution businesses, the reality is that this is not a sustainable approach and there is no merit in pursuing this approach. It is clear that even an institution like Eskom (recognising that Eskom had not invested significantly in new generation during the period of comparison), invested less in capital expenditure over the last decade as reflected in the significant improvement in their debt to equity ratio which improved from 2,93 in 1986 to 0,04 in 2005. In analysing the industry asset base per distribution business it suggests that there is limited correlation between what is taken out of the business, what the business investment requirements are and what the business can sustain over a period of time.

The dependency of current asset owners, in particular municipalities, on the surpluses derived from their electricity businesses to support other activities is recognised. With respect to municipalities, the business transaction will be structured such that the audited surpluses derived from their electricity businesses will continue to flow to the relevant municipality after the restructuring. Transfer of funds from the relevant RED to the relevant municipality will take place on a frequency as agreed to between the two parties to address cash flow considerations. Furthermore municipalities will still have access to the current credit control instruments. Therefore there should be no risk to any municipality from a cash flow or credit rating perspective subject to good municipal governance and effective municipal management. In the case of Eskom Holdings, compensation for their asset contribution will be dealt with in accordance with the asset transfer framework to be agreed upon.

Customers

Serving the customers effectively, irrespective of customer category and in particular support to poorer households, is high on the restructuring agenda which the current industry structure is not able to effectively address. There are many examples in the current industry of significant inconsistencies in tariffs, service standards, roll out of socio-economic policy, customer options and choice. Since the future REDs will be a service provider in a newly-defined area with a more representative customer base, standardisation can be introduced while important socio-economic instruments such as electrification and free basic electricity (FBE) will be rolled out in a consistent manner and will reach the targeted customer segment. It is acknowledged that in the current industry there is cross-subsidisation and for example in the 2003/4 financial year, Eskom subsidised their direct domestic customers and direct landrate customers to the order of R2,1-bn. While cross-subsidisation cannot easily be removed it is envisaged that the EDI under REDs will move to more cost-reflective tariffs. The need for tariff cross-subsidisation to poorer customer categories is recognised. However the importance of transparent subsidisation is also recognised. Tariff harmonisation is envisaged to take place over a five year period and a balanced approach will be adopted to assist the government in addressing poverty challenges, while all customers will enjoy a clear pricing signal which is essential in terms of poverty alleviation, economic growth and business sustainability. It is essential that the tariff harmonisation initiative is informed through an extensive cost of supply study.

From a business model perspective it is envisaged that all electricity customers currently served by municipalities will transfer to the relevant RED while all Eskom Distribution customers with an electricity consumption of less than 100 GWh per annum at one consolidated point, will transfer to the relevant RED. All customers, irrespective of size, where applicable, will contribute to the wires charges associated with the delivery of energy. Although the intention is not to introduce customer choice at this stage, it is envisaged that the National Energy Regulator of South Africa (NERSA) will have to give this matter urgent attention to avoid a market establishment by default. Furthermore the RED business model is designed to accommodate future competition in the electricity market should it be introduced.

Staff

The EDI is currently experiencing a significant skills shortage which immediately offers the opportunity for reskilling and providing development opportunities for the staff employed in the industry. Recent surveys in the EDI suggest that the average age of the largest percentage of the technical staff is >50 years. It is of interest to note that there is a reasonable correlation between this finding and what is experienced in countries like the United States, United Kingdom and Australia. The challenge is therefore a global challenge and it can be expected that there will be more opportunities internationally for skilled South Africans and therefore there is a need to train more than what is required in the local market. The future EDI should be able to provide secure employment and present more opportunities for development and growth. Based on current analyses there is no reason to believe that staff employed in the electricity distribution industry will experience job losses as a result of the restructuring.

Assessment of global EDI reform

In assessing the global EDI reform success rates, it is interesting to note how quickly blame is apportioned to the restructuring initiative for current incidents which can be directly linked to "sins of the past" or inefficient reform management. The lack of, amongst others, capital investment in infrastructure, effective asset management, loss of critical skills, lack of transfer of institutional knowledge and poor management by the business owners prior to the restructuring in many cases creates the worst business challenges during and immediately after restructuring. Examples of where restructuring had to take the blame "in the eyes of the public" are amongst others the Auckland power failure, California blackout and some black outs in Brazil. It is therefore clear that restructuring is not an overnight quick fix solution; it requires time and in many cases significant capital and other resource investment to turn the industry around. However, what is important is that the longer the restructuring is delayed the more complex the turn around strategy becomes, the higher the risk that things

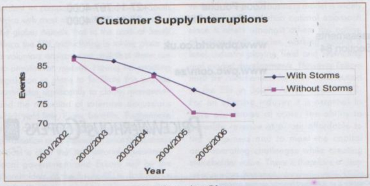

Fig. 1: Source data: Ofgem.

will further deteriorate before it gets better and the longer it will take to realise the restructuring benefits. Where companies were faced with significant capital requirements it become a challenge to provide returns above the cost of capital. While it is recognised that some of the restructuring initiatives did not meet all the reform objectives there are sufficient success case available to provide comfort that the EDI reform in South Africa will be a success, subject to us learning from both the successful as well as the not so successful global transformation initiatives. It is therefore critical that the restructuring takes place before the "expiry of the sell by date" of the reform process and the ability to realise the restructuring benefits in the medium term.

Based on some research, there is no conclusive evidence which suggests that there is any significant performance and efficiency difference between private and public electricity companies. Therefore, the model proposed for South Africa which will see the industry operating as a public entity with national government, local government and Eskom as the shareholders is regarded as an appropriate option. Furthermore this model will position the REDs to meet inter alia the asset investment and electrification challenges facing the industry. Global EDI reform, where effectively implemented, indicates the following:

- Improved service delivery
- Customer supply interruption reduction
- Improved business efficiencies: reduction in technical losses; reduction in non-technical losses; and metering and billing
- Total factor productivity (TFP) improvement: 2,14% Victoria (Australia); and 1,80% Tasmania (Australia)
- Shared services creates opportunities and contributes to efficient businesses.

Fig. 1 illustrates the improvement over the period 2001/02 to 2005/06 in the managing of customer outages in UK businesses, which reinforces the benefits which can be derived through the correct focus.

In considering the relevance of the information reflected in the graph above it is important to note that the electricity distribution industry in South Africa has significant potential for improvement in the managing of customer supply interruptions as well as reducing the technical and non-technical losses. The graph below indicates the progress made by the UK electricity distribution businesses in reducing technical losses. It is important to note, that relative to South Africa, the businesses in the UK started their technical losses improvement from a lower base than what is the case is in South Africa. This implies that the opportunity for improvement in the management of technical as well as non-technical losses is higher than in the case of the UK.

Furthermore the global trend clearly supports

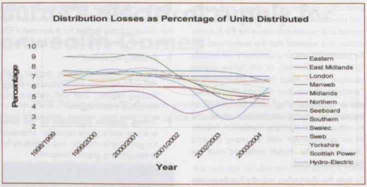

Fig. 2: Source data: Ofgem.

well-defined wires and retail businesses with specific focus on service delivery. There are examples of restructuring initiatives with a marked focus on cost cutting, however this is clearly not a sustainable strategy and it reinforces the need for a holistic approach to efficiency improvement and business optimisation. By its nature the wires or engineering component of the electricity distribution business is a monopoly business. It is therefore important that a strong regulatory regime must be in place to ensure that the industry operates effectively, that the customers' interest is protected and that open access to the distribution networks is allowed. Furthermore, a sound regulatory regime complements the risk profile of the distribution business and hence improves investor confidence which is very important. In analysing the restructuring experience in Australia there is a clear indication that it is essential for the successful functioning of the electricity market that the rules be established upfront and that the market be established. Sound administration is required to administer the legislative framework within which the market must operate and natural monopoly businesses require effective regulation.

What clearly influences the level of performance of any business is the quality and ability of the leadership and management to ensure that shareholder value is created, that the customer interest is looked after and that the business meets its socio-economic responsibilities. Hence the correct recruitment and placement of the right leadership and management is critical.

While it is important to learn from the global experience, the RED establishment experience in South Africa, and in particular RED 1, should not be ignored. In June 2005 RED 1 was established as a municipal entity, wholly owned by the City of Cape Town. Due to the absence of an asset transfer framework which could facilitate the transfer of the electricity distribution related assets from Eskom and the City of Cape Town to RED 1, a contractual mechanism had to be designed to allow RED 1 control over the electricity business within the area of jurisdiction of the City of Cape Town. Furthermore, staff transfers could not take place, agreement could not be reached on compensation for asset contribution and therefore the business arrangement had to be structured through contractual arrangements between RED 1 and the parent entities while these key aspects were still to be negotiated. The absence of appropriate enabling legislation further complicated the establishment of RED 1. RED 1 was liquidated by the City of Cape Town during 2007 and the Service Delivery Agreement which the City had with RED 1 was cancelled. What is however important to note is the contribution made by RED 1 during its period of operation which inter alia includes:

- Significant progress towards an integrated electrification delivery
- Introduction of effective control mechanisms to manage the Eskom-related power supply limitations
- Introduction of benchmarking
- Highest infrastructure capital investment in their area of supply

Conclusion

The EDI restructuring history in South Africa dates back to the early 90s and while it is recognised that based on international experience, reform in the electricity industry takes time, it is essential that the EDI reform in South Africa will very soon see the first REDs up and running. Progress is essential to provide comfort to the 8,3 million customers served by this industry, to create investor confidence, to support the projected economic growth and to provide security to the 31 000 employees directly employed in this industry.

If the ESI is not restructured and an effective electricity market is not developed, it is most unlikely that independent power producers (IPPs) will come and invest in the South Africa energy market. It is essential that a well defined market must be established to provide clear business signals to energy producers as well as customers and investors. Without a defined market and appropriate market rules it is very difficult to predict future opportunities, production requirements, returns, cost signals and investment risks. In the absence of a defined market and no certainty about the ESI business model, it is essential that the restructured EDI be positioned in such a way that it will be able to respond effectively to any future market structure. South Africa cannot afford another "electricity distribution industry restructuring within a restructuring". The complexity of selecting an appropriate business model and to restructure an electricity distribution industry in an environment with so many aspects pertaining to the market undefined must not be underestimated.

To date the distribution industry has been very fortunate that the focus on the generation and transmission capacity challenges overshadowed the challenges in this sector. However considering a potential economic growth of 6% and taking into account what Eskom is currently investing in addressing the generation and transmission challenges, it is a given that should the EDI continue at its current level of performance, it will not be able to sustain the potential economic growth, power failures will increase and the cost to operate will follow the same trend. It is therefore essential to ensure through transparent regulation and clearly defined mechanisms that effective electricity service delivery takes place and that the restructuring of the EDI be accelerated while there is still limited time to rescue the current situation.

Based on international research and the realities of the South African experience, it is evident that the critical success factors for a successful EDI reform and sustainable REDs are inter alia:

- Enabling legislation.
- An established electricity market: well-defined rules; clear and transparent energy trading regime; and well-defined and transparent tariff regime
- Strong, credible regulation for the wires business and a single regulator: incentives for good performance; and incentives for meeting future growth demands.
- Oversight to ensure grid integrity.
- Open access to the distribution wires underpinned by defined access rules and charges.
- Customer protection.
- Customer choice.
- Agreement with the key legacy asset owners to participate in the RED establishment
- Well-defined RED governance structure: sound leadership, effective management and competent staff.
- Managed reform process.

While the journey towards sustainable REDs might be challenging at times, all the research indicates that EDI reform in South Africa has the potential to go down in history as a successful case study. The challenge is, however, to get the right level of stakeholder commitment and for the current industry leadership to recognise that the national interest, the growth of the country and the long-term sustainability of both the EDI and the legacy entities are more important than the potential short-term gains achieved by any particular entity resisting the process.

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Preparing Melbourne's electrical supply for the 2006 Commonwealth Games

by Keith Frearson, Sinclair Knight Merz and Neil Watt, manager network development, Citipower, Australia

The biggest event ever staged in Victoria, the 2006 Commonwealth Games, presented an enormous challenge to the CitiPower and Powercor Australia distribution business, owner and operator of the electricity distribution networks which served almost all of the games venues.

CitiPower Powercorp Australia responded to the event by forming a specific operational management structure to supplement its normal business operations and long term planning. In the lead up to the event, 16 MVA of additional capacity and over 10 MVA of portable generation was installed.

During the eleven days of the event in March 2006, CitiPower and Powercor Australia maintained the power supply to all venues without loss of service.

This outcome was due to extensive pre-planning, risk analysis and a carefully defined operational plan. Collaborative relationships were formed with the event organizers and government bodies that resulted in CitiPower and Powercor Australia playing a leadership role in defining and then meeting power requirements. These relationships will endure and aid future endeavours.

This paper looks at the risks, impact and expectations on a power utility as it responds to a significant multinational and globally broadcast event taking place within its supply area over an extended period. It summarises the lessons learned through what proved to be an extremely successful response by CitiPower and Powercor Australia to its service delivery responsibilities.

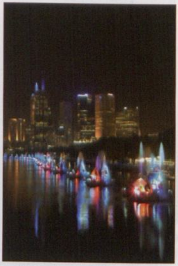
Introduction

Held over 11 days in March 2006, the Melbourne Commonwealth Games was the biggest event ever staged in Victoria. The following statistics give an indication of the size of the event:

- 71 nations or territories participating
- 7200 athletes and officials
- 3100 media representatives
- 1,6-million tickets sold
- 90 000 visitors

All the major venues were in the CitiPower network area in the inner suburbs of Melbourne. Three of the other six venues were located in the Powercor supply area in regional cities around Victoria.

CitiPower and Powercor Australia are two of the five electricity distribution businesses



The Yarra River during closing ceremony.

supplying the State of Victoria. Although they operate separate networks, the companies operate largely as a single entity. They are jointly owned by the Hong Kong-based Cheung Kong Group, and locally listed Spark Infrastructure.

Games venues were supplied at medium voltage (11 kV in CitiPower and 22 kV in Powercor) and other smaller venues at low voltage (415 V/240 V). The sub-transmission network supplying this system is run at 66 kV for both CitiPower and Powercor.

This was the first time that all major venues were operating at full capacity at the same time together with an extensive open space cultural programme attracting around 100 000 people nightly. It was comparable to having the Australian Football League Grand Final, the Formula 1 Grand Prix, and the Australian Tennis Open all at the same time continuously every day for 2 weeks. The Melbourne CBD was an extremely busy place during this time!

What is seldom recognised are the power infrastructure impacts and the requirements to support such an event. It is only when supply fails that the power utilities are noticed. In this day and age, reliable electrical supply is taken for granted.

Melbourne 2006 and the Office of Commonwealth Games Coordination (OCGC) were the event organisers; they engaged three contractors. These three contractors were allocated different aspects of the games organisation, including major venue supply arrangements, broadcasting, public domain areas and project management. CitiPower/Powercor had to deal with all three contractors separately.

This paper looks at the management of electricity supply for this event in terms of power infrastructure assets, incident management, resources, service levels, and business reputation. By outlining the process that was adopted to deal with the risks identified, distribution businesses that face similar events in the future can usefully draw upon this experience.

Risks and assessment

Research began some 18 months prior to the games into what organisers and government expected from CitiPower and Powercor. For example, what loads could be expected at major venues? Organisers were not ready for questions like this, but this did not stop the proactive approach.

The Sydney-based electricity distributor Energy Australia was contacted regarding their experience with the 2000 Olympic Games. This aided the preparation process as critical risks were highlighted.

Extensive analysis was conducted of critical high voltage feeders supplying all venues, existing asset capacity, contingencies and resources. This analysis provided the basis for a games-specific risk management assessment, and external experts (engaged through the Sydney and Athens Olympic Games) were also engaged to critique and enhance these plans.

System stress tests were conducted to establish a load benchmark prior to load build up and to verify loads connected. This involved major venues turning on all their electrical equipment at the same time.

CitiPower's board of directors was committed to doing their part to contribute to making the the games a success and endorsed fully the management approach and operational plans that were developed to minimise outages and optimise response during the event.

The fact that normal average outages were reduced by half for the period showed that good management and not just good luck delivered these results.

Key focus areas

It was important to ensure that attention was paid to more than just the electrical assets. Thus the business's strategies targeted:

- *Assets:* for capacity, maintenance and system integrity
- *Image:* for reputation and media
- *Incident management:* for 24/7 responsiveness
- *People:* for resources to provide the enhanced service level
- *Service:* to ensure we continued to meet customers' normal daily needs during the event
- *Stakeholders* – for successful relationships and meeting their expectations

With these focus areas in mind, careful attention was given to planning and operational phases. The business's protocols and procedures for the games period had to be clearly defined to ensure a very systematic approach for this project. Load augmentations and pre-emptive maintenance certainly needed to be completed well before the games start as well as accreditation and access issues.

Learning from the 2000 Olympics

CitiPower/Powercor met with Energy Australia to share its Olympic experience. From this, the following "learnings" were identified:

- Security of supply to high profile events and broadcast facilities is critically important
- Minimise other works during games to lessen the risk of voltage fluctuations
- Communication strategy to games control and venue management
- Site lockdowns and venue access restrictions must be well managed (personnel and equipment)
- Use existing processes that work well
- Be prepared for last minute requests and changes

Key risk areas

From the key focus areas and "learnings" from Energy Australia, the main risk areas were specifically identified as:

- *Opening and closing ceremonies:* these events would present the greatest load, crowd volume, dignitaries, and media attention.
- *Damage to underground assets:* was a possibility when temporary facilities (marquees, tents, etc) were being erected using ground driven stakes. This was mitigated with daily patrols of assets during the games setup phase.
- *Overall system load:* presented high risk due to variable factors such as weather. The previous year's system maximum demands were also in March (the time of the Melbourne Games). The co-incidence of load during the games was also unknown. System stress tests helped to give an idea of the expected load.
- *Asset failure:* due to overdue maintenance or inspections. All venue feeder maintenance and vegetation management were brought forward and all loads continuously monitored.
- *Access to assets:* an issue for the lead up to and during the event. Appropriate accreditation for staff and vehicles was essential and proved to be the most challenging. CitiPower Powercor did not want a situation where a simple fuse failure would interrupt critical equipment during the opening ceremony for minutes which would be broadcast around the world.

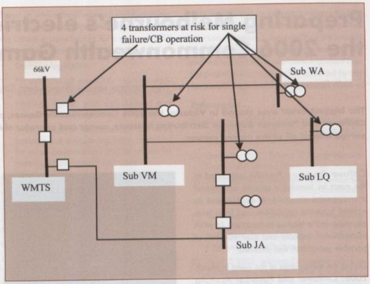


Fig. 1: Multiple transformer-ended feeder configuration.

Historical Melbourne CBD supply failure

The Melbourne central business district (CBD) electricity supply suffered two outage incidents in 2001 which prompted a review of the network design – particularly the appropriateness of the security standard. The review was carried out jointly by Sinclair Knight Merz (SKM) and Citipower.

In both events initial plant outages were followed by secondary faults a number of days later that resulted in loss of supply to areas of the CBD. The review found that there was little or no flexibility to reconfigure the 66 kV sub-transmission network after an outage (either planned or unplanned) and this lack of flexibility was one of the major reasons behind the two outages. To provide improved network flexibility would effectively require the network to be designed to a higher security standard.

The key finding of the review was that although Citipower was following their current (N-1) planning criteria, if the CBD sub-transmission network had been designed to higher security/planning standards (eg "N-1 Secure" or "N-2"), the CBD outages of 2 January and 9 November 2001 could either have been avoided or reduced in severity.

SKM recommended elimination of multiple transformer-ended feeder configurations by adding new switchgear at several critical sites. With the existing configuration, a single 66 kV circuit supplies a number of transformers at different substations but with only one circuit breaker – at the source. All switching and isolation is usually achieved by means of manually operated isolators. A forced outage would take out a number of 66/22 kV transformers albeit at different locations (see Fig. 2). The network has been designed with an "N-1" security standard so that the loss of any single transformer does not cause customer supply interruption. The design has usually proved adequate in the past, however, in the event of a prior transformer outage, a subsequent fault elsewhere in the network could cause tripping of an additional 66/22 kV transformer and result in total loss of a substation (due to overloading of the remaining transformer).

The improved 66 kV switching capability could only be achieved by rebuilding or refurbishing existing substations at considerable expense because of space limitations.

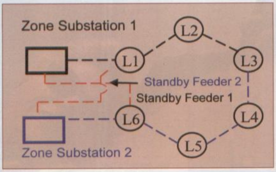


Fig. 2a: Existing MCG lights arrangement.

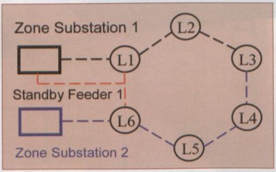


Fig. 2b: Altered MCG lights arrangement.

It was also recommended that additional 66 kV ties between 220/66 kV terminal stations be created to provide improved load transfer capability. These ties would ensure supply reliability in the event of a catastrophic failure of a 220/66 kV transformer and would support the move to the recommended higher security standard.

Comparison of Melbourne CBD supply security

In 2003, SKM conducted a confidential survey of eight national and international cities which could be considered, by the nature of their population, electrical loading and business activities to be "similar" to Melbourne. These cities all had CBDs with electrical loading of between 200 MW and 700 MW (Melbourne). The electricity systems supplying these cities were then ranked from "most secure" to "least secure" on the basis of their current documented security criteria, and on the actual compliance with that criterion as represented by an assessment of the load (MW) at risk under specified N-1 contingency conditions.

The CBD of Melbourne ranked second lowest on the "security of supply" scale of those cities surveyed, even though it had the highest CBD load (700 MW) of those cities.

Infrastructure impact

Load requirements

Once individual games venue loadings were provided, a number of network augmentation projects were carried out. These projects were identified early and construction was completed 3 months before games start.

The projects carried out were for two specific and distinct reasons:

- *Increase security of supply to major venues:* installing significant standby or alternate supply capabilities and introducing additional backup feeders.
- *Increase available capacity at the main venues:* upgrading transformers or installing additional transformers.

The CitiPower CBD high voltage network is arranged such that 11 kV feeders are able to run to their maximum capacity. These feeders are then arranged into groups where each feeder group has its own dedicated standby feeder. A feeder group can consist of up to 10 feeders in some cases. In the event of a contingency, the standby feeder will be switched in to support the load from a faulted feeder.

The standby arrangements at each games venue existed but were extensively reviewed. An example of one of the projects identified was the introduction of a second standby feeder into the MCG. Initially, one feeder was providing backup for the feeder group consisting of nine 11 kV feeders.

This situation was deemed to be high risk as this particular feeder group supplied 4 major games venues in close proximity to each other. In the event of a contingency, the single standby feeder would not be able to provide support for the remaining venues if another contingency occurred. This was a new scenario as not all venues have previously operated concurrently. Therefore a second standby feeder was introduced from a separate zone substation. This increased reliability especially in the case of the 6 MCG lights supplied at 11 kV. The newly introduced standby feeder then continued beyond the lights to support the other venues.

It was observed that although the load estimates provided by the games consultants seemed appropriate, they did not take into account harmonic components. The significant amount of extra lighting and computers/laptops present at venues (due to extensive broadcasting facilities) would add at least 10% to the load figures provided due to the harmonic content. With this in mind, additional capacity was installed through the use of extra transformers and by upgrading existing transformers.

Other works included installing two 1,5 MVA kiosk substations along the nearby Yarra River for dispersed cultural events. These kiosks supplied low voltage distribution boards that supplied cables running underwater to supply the extensive Flotilla Parade of 71 fish along the Yarra River representing the competing nations. The kiosks also provided supply to numerous big screens and other performing arts facilities. Prior to the games there were no installed assets in this area, and now these kiosks remain after the games to support future events.

For low voltage-supplied venues, it was confirmed that each venue substation had a suitable low voltage inter-connector to an adjacent substation. This ensured that in the case of a transformer fault, limited supply could still be provided whilst the equipment was being repaired.

Inspection and maintenance

Asset maintenance was a high priority. All scheduled inspections were confirmed to be within policy. Additional substation, public lighting and reliability patrols were organised on a daily basis. These patrols identified any structure being erected in the vicinity of overhead assets ("no go zones"). Corona (ultraviolet) and infrared surveys of key assets were also conducted prior to the games commencing.

All planned maintenance on assets supplying venues was undertaken earlier than planned including zone substation equipment, high voltage insulator washing and vegetation management.

A specific distribution substation maintenance checklist and audit regime targeted at all venue feeders was established to deliver optimal asset performance. Substations were inspected to confirm ring main unit types, high and low voltage switchgear currently installed, ventilation, condition of fuses, and mobile phone reception.

Work restrictions

Many games venues were "locked-down" one month before the start of the games. This greatly affected access to assets in terms of routine maintenance, planned network and customer projects, and fault response.

CitiPower and Powercor self-imposed several work restrictions in order to mitigate the impact of games restricted areas, risk of disruption to electricity supply and visual or traffic impact in key areas. This included rescheduling planned works outside of the games period, not working on feeders or zone substations supplying key venues, and restricting all planned works across CitiPower network near major venues or the CBD. These restrictions also catered for road event routes such as the Queen's baton relay and several road-based event routes.

Works on sub-transmission lines were also restricted. Verification was sought and gained that no upstream transmission asset works (SP Ausnet) would affect zone substations supplying key games events. Load shedding schedules were reviewed and revised in order to avoid impact on games venues.

Some projects however were still permitted to go ahead provided they did not impact any games venues or if they addressed a health and safety issue.

Enhanced field response

A roster of on site field technicians was organised to attend and monitor many venues in order to minimise switching times and to avoid access issues.

Whilst at these venues, the field technicians reported current, voltage and transformer temperatures on an hourly basis to the control room where this data was entered into a specially designed load monitoring model. This model contained a single line diagram of each major venue substation with the utilisation of each asset clearly visible at all times.

This data was linked to a self-updating graph to give a full load profile at anytime, at any venue.

Alarm and critical alarm levels were marked on the graph. This greatly improved system status reporting as well as the ability for the control room to identify overloads before critical limits were reached.

Additional dedicated fault response units (flying squads) were also deployed during the games period. This was done in conjunction with ensuring spare equipment was placed at strategic sites as well as having standby generators available. The access restrictions imposed by venues meant that bringing in large equipment such as transformers in response to a significant outage would be extremely difficult. It was determined that standby generators would be of greater value and these were designated at specific locations.

Public lighting and general asset patrols were also undertaken daily during the games period.

Other activities

Extra efforts to aid the business during the games period also included information technology and telecommunications support for the operations base. This included a ban on system changes by other CitiPower business units (information technology, telecommunications, and the customer call centre) for the duration of the games.

Venue protection operating points were recorded to ensure a proactive response to potential overloads. Minimum operating settings for venue transformers were the main focus. Fuse sizing, condition, and stocks were reviewed for low voltage distribution substations given that fuse life deteriorates with high load and high temperature.

Onsite generation provided by M2006 at each venue was also verified prior to games commencement.

The system stress tests of venue loads were conducted 2 months before and again 2 weeks before games.

Incident management

The CitiPower network contingency and escalation management plan arrangements were enacted for the duration of the games. The Victorian electricity supply industry operates at contingency escalation levels from 0, to the most severe level 5. For the period of the games, the CitiPower network management team operated at a minimum Level 3 escalation status, instead of the normal Level 0 or 1.

The results

All the initiatives, guidelines, restrictions and work procedures during the games were put into an operation plan document.

After implementing this operation plan, the overall results were as follows:

- Demand – 116,8 MW more than the same period last year
- Energy - 13 000 MWh more than the same period last year
- Capacity – 16,4 MVA installed and 10 MVA portable
- Assets - 140 maintenance activities brought forward.
- Reliability (for the fortnight) - customers off supply 4451 (average 7011).
- Staff - 68 directly involved over the 2 weeks on rosters with another 115 indirectly involved in the lead up.

No outages were sustained at any of the main Commonwealth Games venues.

Legacy

As result of the projects carried out, the following network benefits were realised:

- Enhanced infrastructure to major venues and open space areas
- Minimal outages
- Significantly enhanced reputation with stakeholders
- Whole of business support
- Increased revenue for the period

The Commonwealth Games also presented a chance to extensively test the CitiPower-Powercor network and its associated contingency plans. This in turn tested the processes and systems currently in place as to their effectiveness for network reliability.

Learnings for others

- Ensure extensive pre-planning
- Engage all stakeholders and forge successful partnerships

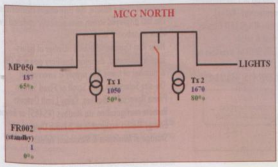


Fig. 3: MCG North single line diagram.

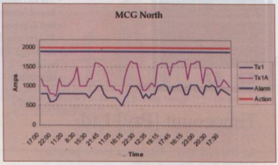


Fig. 4: MCG North load profile.

- Ensure normal rosters and emergency plans are not compromised
- Pro-actively chase load requirements early
- Get a seat in the games central operations centre
- Lock in resources and schedules early
- Deploy a full time resource to manage the project and actions register
- Secure appropriate accreditation and access for staff and vehicles
- Define work restrictions and no-go areas
- Prepare for security lockdowns and road closures
- Prepare for last minute requests
- Confirm who is funding projects and get acceptance in writing
- Ensure all sites/assets are secured physically and monitored continuously
- Test emergency backup plans, particularly communications
- Be aware of changes to venue control and command
- Test access, accreditation and contingencies as lockdowns occur
- Monitor load build up at all venues
- Conduct desktop scenario exercises and system stress tests
- Establish clear responsibilities for the games management team

Term	Description
N-1	The network can withstand the loss of any element and maintain supply to all customers.
N-1 secure	The network can withstand the loss of any element and maintain supply to all customers. In addition the network can be subsequently re-configured to withstand a further outage. During the time taken to re-configure, the network is at risk.
Modified N-2	The network can withstand the loss of a critical element together with the further loss of a non-critical element. This security standard has been applied to the Sydney CBD.
N-2	The network can withstand the loss of any 2 network elements and maintain supply to all customers. Very few networks have true N-2 security.
Satisfactory operating state (Section 4.2.2 NEC)	Term used in National Electricity Code to describe a power system that is able to provide electricity in a stable manner and within the prescribed technical envelope (voltage, frequency, fault levels, ratings, etc). However, such a system may not cope with a network outage and is considered to be "at risk".
Secure operating state (Section 4.2.4 NEC)	As for "satisfactory operating state" but with the addition of a capability to withstand the occurrence of a single credible contingency. Such a system is considered to have a security standard of (N-1)

Table 1: Definition of terms.

- Operate at heightened incident escalation Levels
- Build on existing processes as much as possible rather than establish many new processes

Source

This document is a summary of the following papers:

[1] Watt, N 2006. "Planning and Managing the Electricity Supply for the 2006 Melbourne Commonwealth Games", paper presented to the Electric Energy Society of Australia Annual General Meeting 2006.

[2] Frearson, K & Watt, N. "Improving CBD Security of Supply". Δ

ESI preparedness for the 2010 FIFA Soccer World Cup

by Clinton Carter-Brown, Eskom (chairperson of the 2010 ESI Forum) and Peter Fowles, AMEU

In the winter of 2010 the eyes of the world will be focused on South Africa for the FIFA Soccer World Cup (SWC). South Africa and the African continent will be showcased.

Millions of viewers will tune in to matches, the broadcast of which will be critically dependent on the provision of uninterrupted high quality electrical power. Electrical supply problems that disrupt matches or broadcasts will reflect poorly on the entire electrical supply industry (ESI), South Africa and Africa. Furthermore the load associated with an estimated 300 000 to 500 000 foreign visitors may cause problems in local distribution networks.

2010 load and the electrical supply chain

The main electrical loads associated with the 2010 SWC include:

- *Stadiums:* the 10 stadiums in 9 host cities at which the matches will be played.
- *Base camps:* each of the 32 teams will have a "base camp", and are expected to arrive at base camp up to 2 months prior to the start of the tournament. Base camps could be located anywhere in southern Africa, including neighbouring countries.
- *Training venues:* before each match (typically 5 days beforehand) teams will move from their base camps to the training venues within the host cities (4 training venues per host city).
- *Fan parks:* FIFA fan parks are expected to be located in host cities and other cities, including cities outside of South Africa.
- *FIFA hotels:* hotels at which FIFA will establish their local offices and command centre.
- *Media centres:* journalists will be hosted at the International Broadcast Centre which will form the hub for broadcasting and reporting.
- *Supporters:* the accommodation, tourism and transport needs of visitors.

In relation to the South African peak demand, the magnitude of the additional electrical load is expected to be relatively small. Complexity and risk arise due to the uncertain nature of this load, including its location. Certain loads, such as stadium lighting and broadcasting, have onerous power quality requirements. A momentary interruption or voltage dip could disrupt broadcast to millions of viewers.

Fig. 1 illustrates the key 2010 related loads and the electrical supply chain. The following should be noted:

- All stadium supplies are located within host city municipal supply areas. As municipal generation is limited, the host cities are dependent on Eskom for supply. Host cities may be supplied via Eskom distribution, or directly from the Eskom transmission network at e.g. 275 kV.
- The internal stadium distribution networks supply individual loads such as stadium lighting.
- Other loads situated in South Africa such as base camps, training venues, fan parks, FIFA hotels, media centres and supporter accommodation, tourism and transport will fall in both Eskom and municipal supply areas.

A problem in the supply chain (Eskom generation, Eskom transmission, Eskom distribution, municipal distribution or stadium distribution) will reflect poorly on the entire ESI, South Africa and Africa.

It is critical that all role players in the ESI work together to minimise risks and optimise approaches. Role players include:

- Eskom.
- Host cities and municipalities.
- Owners of the 2010 event stadiums.
- 2010 local organising committee (LOC).
- Association of Municipal Electrical Undertakers (AMEU).
- Department of Minerals and Energy (DME).
- National Energy Regulator of South Africa (NERSA).
- South African Local Government Association (SALGA)

Strategy to deal with 2010

Eskom and the AMEU established a 2010 ESI Forum in August 2006 with the objective of raising awareness of issues related to the provision of adequate electricity supplies during the tournament. Five meetings have subsequently been convened and attended by representatives from the 2010 host cities, AMEU, Eskom, DME and NERSA. There has been limited LOC participation. SALGA has recently nominated a representative to attend forum meetings.

The forum does not have formal decision making capacity. Its purpose is for information sharing and facilitation. Where necessary, issues and risks are escalated to other role players.

Key electrical risks

The following 2010 related electrical supply risks have been identified:

Increased load due to general load growth

The 2010 tournament coincides with the South African winter load peak with the first match due to be played on 11 June 2010. Load

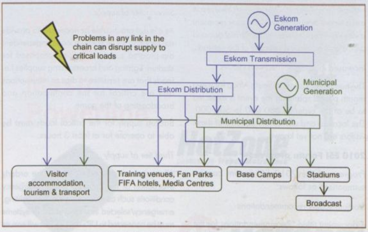


Fig. 1: Electrical supply chain.

growth until 2010 will place further stress on generation, transmission and distribution.

Power quality and security of supply for stadiums

Lighting and broadcasting loads are sensitive to momentary interruptions and voltage dips. A voltage dip to lighting supplies could result in a 40 minute delay due to the lighting cool down and restart times. In addition to ensuring supply adequacy via equipment redundancy, uninterrupted continuity of supply is essential via dip proofing and UPS.

Power quality and security of supply for other critical FIFA loads

Adequate power quality (continuity and waveform) is required for critical FIFA loads such as training venues, fan parks, FIFA hotels and media centres. These loads may be geographically distributed within the host cities and fall within municipal and Eskom distribution supply areas. The locations and magnitudes of some of these loads are not yet known.

Base camps

The decision on the location of base camps is likely to only be made by teams after their group and match venues in the knockout stages of the tournament is known. As the qualifying process will only be completed at the end of 2009, the final 32 teams will probably only make this decision early in 2010. It is anticipated that numbers of supporters will want to base themselves near their favourite team. This behaviour could have a positive economic effect on the area around the chosen base camps as well as an impact on the electrical demand around this area. The scenario of large numbers of supporters following some of the teams during the tournament creates the potential for the electricity demand in the vicinity of some of the base camps to increase by as much as the demand for a small to medium sized town. This may have a huge impact on the electricity network supplying smaller towns/cities/resort areas where this additional load may represent a very significant increase to the normal demand profile and exceed the capacity of the network.

Increased load associated with visitors

The number of visitors to South Africa for a two month period spanning the event is expected to be of the order of 300 000 to 500 000. The location and movement patterns of these visitors are not yet known.

2010 ESI Forum progress

Progress of the 2010 ESI Forum can be summarised as follows:

Stadium supply recommendations

A document titled "Recommendations for the 2010 soccer world cup stadium supplies" has been compiled by members of the forum, and provides guidelines for the electrical supply to, and reticulation within, the stadiums in which world cup games will be hosted. In order to comply with FIFA requirements [1], three tiers of supply are recommended [2].

First tier of supply

- *Preferred Supply:* the preferred supply is the normal supply to the stadium provided by the local supply authority. This supply should be a firm supply via a minimum of two dedicated MV feeders from the local HV/MV substation(s). The preferred supply incoming feeders to the stadium should have unit protection and be operated in parallel ensuring an uninterrupted supply to the stadium in the event of a fault on any one of the feeders. Each feeder must also be capable of supplying the maximum expected stadium load for an indefinite period. Ideally the closest common cause of failure for these supplies should be the main transmission station (MTS) or alternatively the HV supply to the HV/MV substation used to provide supply to the stadium. None of these stadium supplies must be linked to any under-frequency or other automated load management system for the duration of the world cup.
- *Alternate Supply:* the alternate supply should be provided by a set of local generators which are capable of synchronising with, and operating in parallel with the preferred supply. The alternate supply needs to be of sufficient capacity to enable it to independently supply all important stadium loads for a minimum of 3 hours such that games can continue uninterrupted in the event of the complete failure of the preferred supply.

In the event of failure of the preferred supply, the change over operation to the alternative supply (local generation) should be achieved via an automatic changeover system. This should not cause an interruption to any critical loads as addressed via the 2nd and 3rd tier supply recommendations.

Second tier of supply

As it is not practicable or necessary to provide dip proofing for all stadium loads, independent dip-proofed supplies are only proposed for stadium lighting and broadcasting supplies i.e. loads that are sensitive to dips or interruptions and are critical for the continuation and broadcasting of the game.

Backup supply for the critical loads must be able to operate for at least 3 hours.

Third tier of supply

All equipment needed to ensure the orderly evacuation of the premises under emergency conditions such as emergency stadium lighting, emergency/selected lifts, PA and CCTV systems must be connected to UPS devices that will ensure a minimum of 1 hour of normal operation.

DME business plan submission

Each host city has submitted a business plan to the DME identifying the electrical infrastructure projects that need to be funded to support their 2010 effort. The total funding requested by the Host Cities exceeds R2-billion.

Eskom project identification

Eskom has identified a number of projects (distribution and transmission) deemed necessary for host city supply strengthening required for 2010. These projects are bulk infrastructure projects to ensure adequate supply to each host city. Projects that are not already approved are in the process of being included in business case and rolling plan submissions for the 2007/8 financial year and beyond.

Project summary report

A 2010 ESI project summary report has been compiled and summarises the projects identified to ensure adequate supply to and within the host cities [3]. It covers Eskom transmission, Eskom distribution and municipal host city electrical infrastructure projects. It must be noted that the vast majority of these projects are required regardless of the 2010 FIFA tournament, and are essential to meet normal load growth. In some cases the 2010 FIFA tournament has moved the project required completion dates forward. These projects need to be completed in order to ensure an adequate and reliable electrical supply.

Position paper on base camps

A position paper has been drafted on the possible risks associated with 2010 base camps [4]. This position paper is aimed for circulation to municipalities and the accommodation and tourism industry. It aims to create awareness of the possible impact that base camps could have on local electrical infrastructure, and the need to liaise with electrical service providers.

Media statement

A joint media statement has been issued by Eskom and the DME, informing the media of the proactive joint planning initiative and to correct misinformation regarding possible risks.

Activities going forward

The following need to be addressed by the forum in consultation with key stakeholders:

Municipal bulk infrastructure funding

The projects listed in the DME host city business plan submissions have lead times estimated to range between 1 and 3 years. Requirements of the Municipal Finance Management Act make it difficult for municipalities wishing to order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long lead time materials if the funding for these projects has not been confirmed.

It is essential that the projects identified by the host cities are initiated as soon as possible so that required completion dates for the 2009 Confederation Cup and the 2010 FIFA tournament can be met. Further delays may result in required completion dates not being met, with the subsequent risk of power interruptions.

The DME have confirmed funding of R7,5-million for each host city stadium for the 2007/8 financial year. There is however no funding commitment from Treasury (via the DME) for 2008/9 and beyond. The DME indicated that additional funding may be available via the integrated national electrification planning (INEP) unit within the DME. This funding would however be limited and would also be dependent on municipalities not meeting target spending on electrification.

Unless increased funding is made available in the following financial years (via the medium term expenditure framework), the burden of this funding will fall on the municipalities.

In order to mitigate the risks associated with projects that remain unfunded, an assessment of the risks and possible operational contingency plans is required.

Stadium supply recommendations

The stadium supply recommendations need to be disseminated to stadium owners and electrical consultants involved with the stadium electrical design. A review of the stadium electrical designs may be required to assess alignment with the recommendations.

Base camps

The risks associated with base camps should be mitigated as follows:

- The 2010 ESI Forum position paper needs to be disseminated to municipalities and potential base camp bidders.
- Potential base camps need to be identified and the associated electrical networks assessed to identify risks.

Other FIFA loads

The location of training venues is known, however other facilities such as FIFA hotels and communication centres need to be confirmed and the distribution networks assessed.

Visitor locations and movement

Scenarios for visitor numbers, location and movement need to be developed and combined with load models to establish possible loading implications.

Operational planning

In addition to electrical infrastructure capital projects, operational issues need to be addressed. Planned maintenance will need to be coordinated to ensure that generation availability is maximised and network risks (transmission and distribution including Eskom and municipalities) are minimised for the duration of the 2010 tournament.

Operational risk assessment and planning between Eskom and the municipalities is the subject of a companion paper.

Stakeholder liaison

It is imperative that all stakeholders establish close working relationships and work together to ensure that risks are mitigated and problems are addressed in the most effective manner.

Conclusions

The 2010 ESI Forum provides an environment for role players to share experiences, concerns, requirements and plans to ensure that electrical supply risks associated with the 2010 FIFA Soccer World Cup are managed.

Several activities have been identified for further action via the 2010 ESI forum, and will need to be driven via interaction with key stakeholders such as the 2010 LOC.

References

[1] Technical Recommendations and Requirements for the Construction or Modernisation of Football Stadia, FIFA, 2007.

[2] Recommendations for the 2010 soccer world cup stadium supplies, Draft 6a, 2010 ESI forum, August 2007.

[3] 2010 FIFA Soccer World Cup ESI Project Summary, Rev 3, 2010 ESI forum, 2007

[4] Position Paper: Base Camps for the 2010 soccer world cup, Rev 2, 2010 ESI forum, 2007

References 2, 3 and 4 can be downloaded from http://www.ameu.co.za/mediacentre/worldcup/.

Acknowledgements

The authors would like to acknowledge the contributions of all of the members of the 2010 ESI Forum. Δ

Mitigation of operational risks for the 2010 FIFA Soccer World Cup

by P E Fowles, AMEU and A Sprunt, Eskom

The first match of the FIFA 2010 Soccer World Cup (SWC) is scheduled to take place on 11 June 2010 [1]. That is a little more than two and a half years from now when millions of television viewers will be focused on, not only the football matches, but also on the ability of South Africa to organise and stage one of the biggest events in the world.

Considerable media attention has to date focussed on our ability to complete the construction of the required stadiums, improve security, manage transport for teams and visitors, and many other issues related to `out of stadium' activities for which guarantees have been made to FIFA. Relatively little media and organiser attention has to date been given to the provision of secure and reliable electrical supplies to the key areas affected by the tournament. Interruptions to these supplies that disrupt preparations for the event, matches or broadcasts or inconvenience visitors during the window period of the tournament [one month before the start to one month after it ends] will reflect poorly on the entire electrical supply industry (ESI), South Africa and Africa. This paper seeks to identify some of the operational risks associated with the provision of adequate and reliable supplies and suggest some possible mitigation strategies.

Background

Carter-Brown's paper [2] has comprehensively identified the key electrical loads associated with the tournament which include:

- The 10 stadiums in 9 host cities at which the matches will be played.
- Base camps for each of the 32 teams taking part.
- Training venues at both base camps and in the host cities.
- Fan parks.
- FIFA hotels accommodating their local offices and command centre.
- Media centres.
- The accommodation, tourism and transport needs of visitors.

He further observes that the magnitude of the additional electrical load is expected to be relatively small in relation to the South African peak demand, but that complexity and risk arise due to the uncertain nature of this load, including its location.

The inter-connected nature of the South African electricity network is highlighted by Carter-Brown in his Fig. 1[2] to stress that problems in any link in the electricity supply chain can disrupt supply to critical loads. It was this interdependency that resulted in Eskom and the AMEU establishing a 2010 ESI Forum that held its first meeting in August 2006 with the objective of raising awareness of issues related to the provision of adequate electricity supplies during the tournament.

The forum has been relatively successful in bringing a number of the major stakeholders together to discuss a wide range of issues related to the electricity supplies prior to and during the tournament and has compiled:

- A document titled "Recommendations for the 2010 soccer world cup stadium supplies" [3] which provides guidelines for the electrical supply to, and reticulation within, the stadiums in which world cup games will be hosted.
- A template to assist host cities to submit business plans to the Department of Minerals and Energy [DME] in support of applications for funding of electrical infrastructure projects deemed necessary to support their 2010 effort.
- A 2010 ESI project summary report [4] that summarises the projects identified to ensure adequate supply to and within the host cities and includes the Eskom distribution and transmission projects deemed necessary for host city supply strengthening required for 2010.
- A position paper [5] has been drafted on the facilities required at, and possible risks associated with the service to, 2010 base camps.

Key electrical risks

Carter-Brown has identified [2] the following 2010 related electrical supply risks:

- General load growth until 2010 will place further stress on generation, transmission and distribution.
- Power quality and security of supply for stadiums and other FIFA loads.
- The decision on the location of base camps is likely to only be made by teams after their group and match venues in the knockout stages of the tournament are known. As the qualifying process will only be completed at the end of 2009, the final 32 teams will probably only make this decision early in 2010.
- The possible huge impact on the electricity network supplying smaller towns/cities/resort areas close to base camps where teams supporters are expected to stay. This additional load may represent a very significant increase to the normal demand profile and exceed the capacity of the network.
- Increased load associated with an expected 300 000 to 500 000 visitors, the movement patterns of which are not yet known.
- The possible lack of adequate funding for projects deemed necessary for the security and reliability of supply.
- Long lead times for equipment and materials necessary for the identified projects, even if the requisite funding is provided in the near future, is likely to mean that many of these projects will not be completed prior to the tournament.

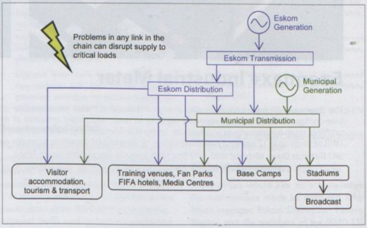

Fig. 1: Electrical supply chain [2].

Operational risks

In addition to the risks associated with the provision of networks that will provide adequate electrical capacity to the needed locations, a number of operational risks have been identified which, if addressed, could mitigate some of the earlier risks discussed:

Generation

The 2010 tournament coincides with the South African winter load peak. The situation of possible shortages of generation capacity will be exacerbated by the increasing level of capital work in the Eskom environment [generation, transmission and distribution] to cope with growth in South Africa's demand. This work will be continuing over the window period of the tournament. Further risks relate to:

- The possibility of unplanned or forced outages of generation.
- The influence of weather on demand as severe cold can result in a load increase of 2000 MW compared to a moderate winter.
- Load growth exceeding industry forecasts.
- The management of primary energy supplies, specifically liquid fuel, due to national requirements as well as reliance on road transport.
- The possibilities of wet coal supplies and of drought affecting water cooled and peaking stations.
- DSM and voluntary load reduction [DMP] contracts may not be able to adequately curtail demand.

Transmission

Risks related to the transmission network are:

- Unplanned outages and the ability to respond to such events arising from movement of heavy equipment and availability of material and human resources should multiple vents occur simultaneously.
- Delays in the build programme [capital work].
- Environmental factors including the possibility of networks being exposed to snow loading and fires.
- Network capacity constraints and unplanned network contingencies.

Distribution

A number of factors are relevant in assessing risk in the distribution environment:

- *Network expansion:* the incidence of capital work involving additions to or upgrading of any network that may influence supply to any of the key electrical loads during crucial periods of the tournament is regarded as a significant risk.
- *Planned maintenance:* a significant portion of planned maintenance takes place during winter months due to the incidence of storm weather during the summer months. This maintenance on networks that could directly or indirectly influence the supply to any of the stadiums is seen as a significant risk.
- *Refurbishment or replacement of equipment:* it is known that some distribution networks in South Africa include items of equipment that are obsolete or in need of refurbishment. Plans for the refurbishment or replacement of this equipment are often hindered by the lack of available funding or long lead times for delivery of the relevant equipment. The risk to network operations is significant if the work on relevant networks is not carried out well before the tournament.
- *Network configuration:* local networks are frequently rearranged due to faults that have not been attended to, to facilitate network additions or to cope with load changes. Abnormal network configurations during the tournament will complicate operations and possibly delay supply restoration.
- *Load shedding plans and agreements:* The availability of adequate generation capacity within South Africa over the last eighteen months has highlighted the importance of load shedding plans and contract agreements. It is possible that a number of the networks critical for world cup events are linked to load shedding schemes. In the event of system instability,

the operation of some or these schemes could affect the events and hence are a risk.

- *Strategic spares:* recent catastrophic events on a number of networks have highlighted the need for strategic spares to be available for use by distributors in the event of such incident[s] during the world cup. Many municipal distributors do not have the financial and other resources to maintain a stock of such spares, which poses a risk.

Human resources

A number of human resource issues pose possible risks including:

- The possible shortage of skilled and experienced staff.
- The demand for leave over the window period of the tournament.
- Demanding standby rosters as well as personnel on site.
- Salary negotiations, with the attendant risk of industrial action, for the municipal, fuel and transport sectors.

Mitigation strategies

It is suggested that the following strategies be considered for implementation to reduce some of the risks.

Generation and transmission

The mitigation of risks for these components is primarily an Eskom responsibility and will include:

- Ensuring adequate primary energy supply prior to the event.
- The management of plans for the taking of generation and transmission plant out of service for planned maintenance or refuelling [Koeberg] in order that the risk to the tournament is minimised.
- The identification and assessment of Infrastructure providing supply to municipal distributor areas, which could directly or indirectly influence the supply to any of the stadiums, for condition and maintenance or refurbishment plans.
- Detailed emergency planning and simulation of these plans prior to the event.
- Plans for obtaining and storing of strategic spares, as well as logistic constraints such as communications and transport should also be developed.
- Contractors to start the inspection of networks earlier than normal practice [March through to June] for those networks identified as critical for reliability and quality of supply.

Distribution

The municipal distributor of each host city in particular, as well as distributors in all areas that may experience an increase of tourism activity over the period of the tournament, should carry out the following preparation work:

- Identify and assess the condition of the electrical infrastructure that could directly or indirectly influence the supply to the stadium[s], training venues and key loads in their area of responsibility.
- Replacement, refurbishment or maintenance of these networks to be scheduled to be completed well before the commencement of the tournament.
- Evaluate the requirement and availability of strategic spares for their network.
- Assess loads connected to load shedding relays and revise existing plans to ensure that there is no impact on identified tournament critical loads should the need for load shedding be required.
- Arrange networks so that no abnormal conditions are maintained during the period of the tournament.
- Prepare contingency plans for supplies to the critical loads and ensure all control and operations personnel are thoroughly familiar with switching requirements.
- Plan leave and standby rosters well in advance to ensure the availability of an adequate level of competent staff.

While the planning personnel in Eskom regions and the host city municipal distributors have been involved to date in discussion of many of the these issues through the 2010 ESI Forum, it is now necessary to involve municipal distributors in other areas if we are going to be successful ensuring a reliable and secure electricity supply over the period of the world cup. In addition to activities described above, these distributors should:

- Identify the possibility of base camps being established in their area of supply.
- Meet with major accommodation and tourist establishments in their area of supply to discuss the expected impact of additional visitors and possible expansion plans on their demand.
- Discuss their own expected demand requirements with their Eskom regional planning manager to enable Eskom to make plans to meet this demand.

Recommended action

The successful implementation of many of the mitigation strategies suggested is unlikely to be achieved without a considerable level of co-operation among the stakeholders involved. It is recommended that, in addition to the continuation of the 2010 ESI Forum activities, Regional 2010 work groups be established to focus on:

- Maintenance planning including the identification of key networks, strategic spares requirements and availability.
- Demand forecasts and associated capital projects planning.
- Operational plans including available resources, contingency planning and under-frequency load shedding.
- The co-ordination of response to unplanned or emergency events including co-ordination between other bodies so that issues like road permits do not become issues during the tournament.

Suggested role players from Eskom and municipal distributors to serve on these work groups are:

- Control personnel.
- Planning personnel for network optimisation, contingency plans and capital programme.
- Field services personnel for maintenance planning and essential spares.
- Regional transmission personnel.

Projects that may have an influence on any of the key electrical loads need to be tagged. These work groups should be able to demonstrate, via some sort of check list, that all issues have been assessed and suitable plans put in place to address these issues.

Conclusions

The 2010 ESI Forum has been relatively successful in raising awareness of many of the issues and challenges associated in the provision of secure and reliable electricity supplies to facilities involved in the staging of the 2010 world cup tournament in South Africa.

Several activities have been identified for further action via the 2010 ESI Forum but much more liaison is required at regional level among key stakeholders to ensure that operational risks are mitigated.

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[3] Recommendations for the 2010 soccer world cup stadium supplies, Draft 6a, 2010 ESI forum, August 2007.

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Acknowledgements

The authors would like to acknowledge the contributions made by Raymond Kodi (plant manager, Eskom Distribution Eastern Region) and the members of the 2010 ESI Forum. Δ

The impact of CIE 140 on street lighting in South Africa

by Murray Cronje, Pr.Tech (Eng.)

This paper briefly discusses the newly published revisions to SANS 10098-1: 1990: " Public Lighting Part 1: The lighting of public thoroughfares", and ARP035:2002: " Guidelines for the installation and maintenance of street lighting", wherein the street lighting calculation methods in the new CIE 140: " Road lighting calculations" are embraced in favour of the now obsolete CIE 30.2: "Calculation and measurement of luminance and illuminance in road lighting".

The paper further takes a deeper look at the differences between CIE 140 and CIE 30.2 and what the practical implications will be on future street lighting installations. The paper also discusses the lighting software that will be required to carry out street lighting calculations in terms of the new calculation methods of CIE 140.

Introduction

The street lighting calculation methods in SANS 10098-1 have all these years been based on the CIE 30.2 document that was published in 1982. This document was published shortly after the luminance concept was accepted as common practice, without much experience in this field during those days.

The calculation methods in CIE 140 bring about several improvements resulting from the experience that has been gained over the past 25 years in street lighting.

The SC 64C technical committee at the SABS have approved the proposed revisions to the SANS 10098-1 and ARP035 documents to incorporate the calculation methods of CIE140, and the amendments were published at the end of September 2007.

Scope of amendments

SANS 10098-1

- All references to CIE 30.2 have been replaced with CIE 140
- The reference to the computer programs listed in CIE 30.2 have been replaced with a reference to Windows based commercially available computer programs which do calculations according to CIE 140
- All design methods are to be based on that of CIE 140
- All design criteria to be based on that of CIE 140
- The photo goniometer laboratory at the SABS will have to change their method of scanning the photometric distribution of street lights to comply with the recommendations of CIE 140

ARP035

- All references to the SABS 098 road lighting computer program have been replaced by references to Windows based commercially available road lighting programs that can do calculations in terms of CIE 140
- The encrypted data files that were unique for use in the SABS 098 computer program only, have been replaced with other data files in a suitable format for the Windows based commercially available programs. The authenticity of these other data files can be verified by comparison to the source data from the SABS
- References to encrypted luminaire data files that are to be submitted with tenders, have been replaced with other electronic data files that have to be submitted together with the SABS source data in electronic format
- References to encrypted data files which are to be created from the intensity tables, have been replaced by other data files that are to be converted by the SABS/ luminaire supplier, from the source intensity tables

Major differences between CIE 140 and CIE 30.2

Road surfaces

The laboratory measurement of the reflection properties of the road surfaces, which was fully dealt with in the CIE 30.2., has been omitted in the new CIE 140 document as it will be the subject of a separate publication to come, as will be field measurements.

Luminous intensity data for luminaires

The coordinate system used for road lighting is generally the C, γ coordinate system (see Fig. 1). Luminous intensity is expressed in candela per kilolumen (cd/klm) for all the light sources in the luminaire.

Values of luminous intensities are required over the range of angles which are important. In particular, values are required up to the maximum angle of elevation which is relevant for the intended application of the luminaire, with allowance being made for the maximum angle of tilt of luminaire.

Angular intervals stipulated in CIE 140 have been selected to give acceptable levels of interpolation error when the recommended interpolation procedures are used, and to keep the time taken for photometric measurements within practical limits.

In the (C, γ) system of co-ordinates, luminous

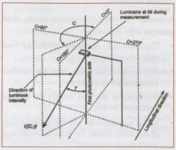

Fig. 1: C, γ coordinate system.

intensities will be required at the angular intervals stated below.

For all luminaires the angular intervals in elevation (γ) should at most be 2,5° from 0° to 90° plus the permissible maximum field angle of elevation minus the measurement angle of elevation, for the luminaire. In azimuth the intervals can be varied according to the symmetry of the light distribution from the luminaires as follows:

- *Luminaires with no symmetry about the C = 0°-180° plane:* the intervals should at most be 5°, starting at 0°, when the luminaire is in its measurement angle of elevation and ending at 355° ;
- *Luminaires with nominal symmetry about the C = 90° - 270°-plane:* the intervals should at most be 5°, starting at 270°, when the luminaire is at its tilt during measurement, and ending at 90°
- *Luminaires with nominally the same light distribution in all C planes:* only one representative set of measurements in elevation needed.

Interpolation of luminous intensity data

Up to the present time, I-tables have usually been measured according the angular spacings recommended in the CIE publication 30.2 – 1982. These spacings are wider than those recommended above, and for these I-tables linear interpolation will not be satisfactory. Quadratic interpolation or


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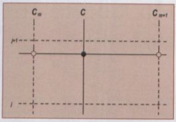

Fig. 2: Angles required for linear interpolation of luminous intensity.

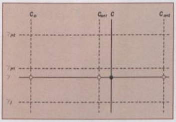

Fig. 3: Values required for quadratic interpolation.

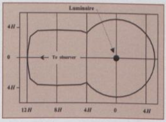

Fig. 4: Plan area covered by r tables.

an equivalent mathematical procedure is recommended.

Linear interpolation

To estimate the intensity I(C, γ) it is necessary to interpolate between the four values of intensity lying closest to the direction (C, γ) as indicated in Fig. 2.

Quadratic interpolation

Quadratic interpolation requires three values in the I-tables for each interpolated value. Fig. 3 indicates the procedure.

If a value of I is required at (C, γ), interpolation is first carried out down three adjacent columns of the I-table enclosing the point. This enables three values of I to be found at γ. Interpolation is then carried out across the table to find the required value at (C, γ). If preferred this procedure may be reversed, i.e. interpolation can be carried out across and then down the I-table without affecting the result.

Road surface reflection data

Road surface reflection data are, conventionally, expressed in terms of the reduced luminance coefficient multiplied by 10 000 (for convenience of presentation), at angular intervals and in directions indicated in Table 1.

The plan area covered by the data in the table is indicated in Fig. 4. in terms of the mounting height of the luminaire, and in relation to the position of the luminaire and the direction of the observer.

The reduced luminance coefficient varies according the angles indicated on Fig. 5.

Interpolation in the r-table

When a value of r is required for values of tan γ and β lying between those given in the r-table it is necessary to use quadratic interpolation, as recommended in CIE 140.

tan γ	β (degrees)																			
	0	2	5	10	15	20	25	30	35	40	45	60	75	90	105	120	135	150	165	180
0,00	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329
0,25	362	358	371	364	371	369	362	357	351	349	348	340	328	312	299	294	298	288	292	281
0,50	379	368	375	373	367	359	350	340	328	317	306	280	266	249	237	237	231	231	227	235
0,75	380	375	378	365	351	334	315	295	275	256	239	218	198	178	175	176	176	169	175	176
1,00	372	375	372	354	315	277	243	221	205	192	181	152	134	130	125	124	125	129	128	128
1,25	375	373	352	318	265	221	189	166	150	136	125	107	91	93	91	91	88	94	97	97
1,50	354	352	336	271	213	170	140	121	109	97	87	76	67	65	66	66	67	68	71	71
1,75	333	327	302	222	166	129	104	90	75	68	63	53	51	49	49	47	52	51	53	54
2,00	318	310	266	180	121	90	75	62	54	50	48	40	40	38	38	38	41	41	43	45
2,50	268	262	205	119	72	50	41	36	33	29	26	25	23	24	25	24	26	27	29	28
3,00	227	217	147	74	42	29	25	23	21	19	18	16	16	17	18	17	19	21	21	23
3,50	194	168	106	47	30	22	17	14	13	12	12	11	10	11	12	13	15	14	15	14
4,00	168	136	76	34	19	14	13	11	10	10	10	8	8	9	10	9	11	12	11	13
4,50	141	111	54	21	14	11	9	8	8	8	8	7	7	8	8	8	8	10	10	11
5,00	126	90	43	17	10	8	8	7	6	6	7	6	7	6	6	7	8	8	8	9
5,50	107	79	32	12	8	7	7	7	6	5										
6,00	94	65	26	10	7	6	6	6	5											
6,50	86	56	21	8	7	6	5	5												
7,00	78	50	17	7	5	5	5	5												
7,50	70	41	14	7	4	3	4													
8,00	63	37	11	5	4	4	4													
8,50	60	37	10	5	4	4	4													
9,00	56	32	9	5	4	3														
9,50	53	28	9	4	4	4														
10,00	52	27	7	5	4	3														
10,50	45	23	7	4	3	3														
11,00	43	22	7	3	3	3														
11,50	44	22	7	3	3															
12,00	42	20	7	4	3															

Table 1: Example r-table of reduced luminance coefficients (x 104 r).

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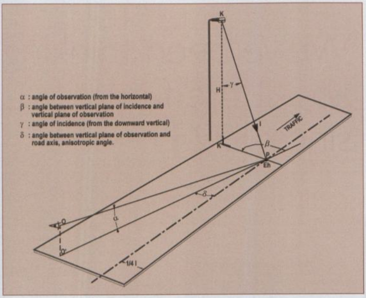

Fig. 5: Angular relationships for luminaire, observer and point of observation.

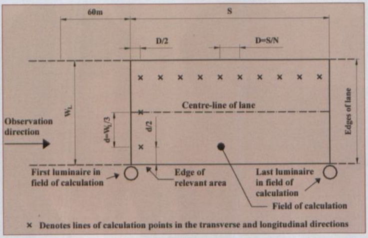

Fig. 7: Position of calculation points in a driving line

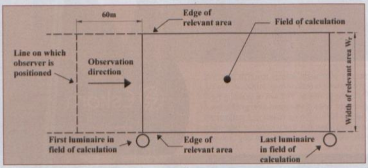

Fig. 6: Field of calculation for carriageway luminance.

Calculation of luminance

Luminance at a point

The luminance at a point is determined by applying the following formula or a mathematically equivalent formula.

$$L = \sum \frac{I(C,\gamma) \cdot r \cdot \Phi \cdot MF \cdot 10^{-4}}{H^2}$$

where :

L = maintained luminance in cd/m²

Σ = the summation of the contributions from all the luminaires

I (C, γ) = luminous intensity in the direction (C, γ) , indicated in Fig. 1 in cd/klm

r = reduced luminance coefficient for a light ray incident with angular coordinates (β, γ)

Φ = initial luminous flux in klm of the sources in each luminaire

MF = product of the flux maintenance factor and the luminaire maintenance factor

H = mounting height in m of the luminaires above the surface of the road.

I (C, γ) = determined from the luminaire I-table after corrections have been made for the orientation, tilt, and rotation of the luminaire and linear or quadratic interpolation, if necessary, applied. Likewise, r for the appropriate value of β and tan γ is determined after the use of quadratic interpolation, if necessary.

Field of calculation for luminance

The field of calculation should be typical of the area of the road which is of interest to the driver.

In the longitudinal direction on a straight road, the field of calculation should lie between two luminaires in the same row (Fig. 6), the first luminaire being located 60 m ahead of the observer.

In the transverse direction, it should cover the whole carriageway width on roads without a central reservation, and the width of one carriageway on roads with a central reservation.

Position of calculation points

CIE 30.2 required five longitudinal axes of calculation points per lane, whereas CIE 140 only requires three. The longitudinal distance between points in these axes is now less or equal to 3 m whereas in CIE 30.2 it was 5 m. The first transverse calculation axis was in front of the pole/luminaire, but has now shifted longitudinally for half of the distance of the spacing between points.

The new calculation points should be evenly spaced in the field of calculation and located as indicated in Fig. 7.

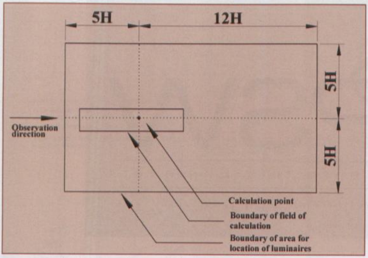

Fig. 8: Luminaires which may contribute to luminance at calculation point.

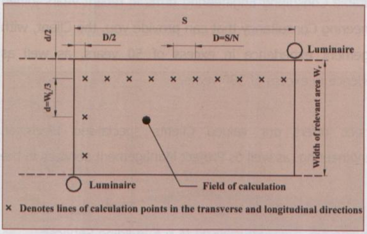

Fig. 9: Calculation points for illuminance.

In the longitudinal direction

The spacing (D) in the longitudinal direction is determined from the equation :

$$D = \frac{S}{N}$$

where

D = spacing between points in the longitudinal direction (m)

S = the spacing between luminaires in the same row (m)

N = number of calculation points in the longitudinal direction chosen such that:

For S ≤30m, N = 10

For S > 30m, N is the smallest integer giving D ≤ 3 m.

The first transverse row of calculation points is spaced at a distance D/2 beyond the first luminaire (remote from the observer).

In the transverse direction

The spacing (d) in the transverse is determined from the equation:

$$d = \frac{W_L}{3}$$

where :

d = spacing between points in the transverse direction (m)

W_L = the lane width (m)

The outermost calculation points are spaced d/2 from the edges of the lane.

Where there is a hard shoulder and luminance information is required, the number and spacing of the calculation points should be the same as for a driving lane.

Position of observer

Previously the observer was ¼ of the carriageway width in from the kerb, for luminance, overall uniformity and longitudinal uniformity calculations. Now the observer is located on the axis of each traffic lane, and for each position of the observer, the luminance is calculated over the whole width of the road. The relevant "operative" values of average luminance, overall uniformity and longitudinal uniformity are the minimum values calculated.

The angle of observation remains fixed at 1° below the horizontal direction.

In the transverse direction the observer is placed in the centre of each lane in turn. Average luminance (L_{av}) and overall uniformity of luminance (U_O) are calculated for the entire carriageway for each position of the observer. Longitudinal uniformity of luminance (U_l) is calculated for each centre-line. The operative value of L_{av}, U_O and U_l are the lowest in each case.

Number of luminaires included in calculation

For each calculation point, all the luminaires which make a significant contribution to the luminance should be included in the calculation. These luminaires lie in the plan area of the r-table (Table 1), which approximates to a rectangle of dimensions 5H by 17H, and by its symmetry can be used to cover an area 10H by 17H (Fig. 4). As a consequence it is only necessary to consider luminaires which are situated within five times the mounting height from the calculation point towards the observer, 12 times the mounting height from the calculation point away from the observer, and five times the mounting height on either side of the calculation point. Fig. 8 shows an example.

Horizontal illuminance

The horizontal illuminance at a point should be calculated from the following formula or a mathematically equivalent formula:

$$E_h = \sum \frac{I(C,\gamma) \cdot \cos^3 \gamma \cdot \Phi \cdot MF}{H^2}$$

where

E_h = maintained horizontal illuminance at the point in lux

Σ = summation of the contributions from all the luminaires

I (C, γ) = intensity in the cd/klm in the direction of the point

γ = angle of incidence of the light at the point

H = mounting height in m of the luminaire;

Φ = initial luminous flux in klm of the lamp or lamps in the luminaire

MF = product of the lamp flux maintenance factor and the luminaire maintenance factor

Field of calculation

The field of calculation should be typical of the area of the road which is of interest to the driver and pedestrian, and may include the footpaths,


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one step coaxial terminations
FIBRE OPTIC
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overhead installation
INFRARED
scanning
TRANSFORMER
testing

cycle tracks and verges. As shown in Fig. 9 it should be bounded by the edges of the carriageway and by transverse lines through two consecutive luminaires.

For staggered installations consecutive luminaires will be on opposite sides of the road.

Position of calculation points

The calculation points should be evenly spaced in the field of calculation (Fig.9) and their number should be chosen as follows :

In the longitudinal direction

The spacing in the longitudinal direction should be determined from the equation:

$$D = \frac{S}{N}$$

where

D = spacing between points in the longitudinal direction (m)

S= spacing between luminaires (m)

N = number of calculation points in the longitudinal direction with the following values: for $S \leq 30$ m, N = 10; for $S > 30$ m, the smallest integer giving $D \leq 3$ m

The first row of calculation points is spaced at a distance D/2 beyond the first luminaire (m).

In the transverse direction

$$d = \frac{W_r}{3}$$

where

d = spacing between points in the transverse direction (m)

W_r = width of the carriageway on relevant area (m)

The spacing of points from the edges of the relevant area is D/2 in the longitudinal direction, and d/2 in the transverse direction, as indicated in Fig. 9.

Number of luminaires included in calculation

Luminaires which are situated within five times the mounting height from the calculation point should be included in calculation.

Calculation of quality characteristics

Average luminance L_{av}

The average luminance is calculated as the arithmetic mean of luminances obtained at the calculations points.

Overall uniformity U_o

The overall uniformity is calculated as the ratio of the lowest to the average luminance.

Longitudinal uniformity U_L

The longitudinal uniformity is calculated as the ratio of the lowest to the highest luminance in the longitudinal direction along the centre-line of each lane, including the hard shoulder in the case of motorways.

The number of points in the longitudinal direction (N) and the spacing between them should be the same as those used for the calculation of average luminance.

The observer's position should be in line with the row of calculation points.

Threshold increment TI

CIE 30.2 had a static observer for the TI calculation. CIE 140 requires a mobile observer at a distance equal to the spacing of the luminaires by an increment which is equal to the spacing of the calculation point for luminance.

The threshold increment (TI) is calculated for the installation in its initial state, when it will have its highest value. It is calculated from the formula:

$$TI = \frac{k \cdot E_\theta}{L_{av}^{0,80} \cdot \theta^2} (\%)$$

where

k = constant which varies according to the age of the observer. It is conventionally taken as 650, which is applicable for an observer of 23 years. Its value for other ages can be derived from the formula.

A = age of the observer in years

E_θ = the total illuminance (in lux per 1000 initial lamp lumens) produced by new luminaires on a plane normal to the line of sight and at the height of the observer's eye. The observer's eye, height 1,5 m above road level, is positioned transversely Wr/4 from the carriageway edge and longitudinally at a distance in metres of 2,75 (H – 1.5), where H is the mounting height (in m), in front of the field of calculation. The line of sight is 1° below the horizontal and in a vertical plane in the longitudinal direction passing through the observer's eye.

L_{av} = average initial luminance of the road surface

θ = angle in degrees of arc between the line of sight and the centre of each luminaire

This equation is valid for
$0,05 < L_{av} < 5$ cd/m² and $1,5° < \theta < 60°$ (CIE 31-1976).

E_θ is summed for the first luminaire in the direction of observation and luminaires beyond, up to a distance of 500 m.

The calculation is commenced with the observer in the initial position stated above and repeated with the observer moved forwards in increments which are the same in number and distance as are used for the longitudinal spacing of luminance points. The maximum value of TI found is the operative value.

Surround ratio SR

The obsolete CIE 30.2 did not consider illuminance on the verge of the road, whereas CIE 140 does by means of a "surround ratio".

The surround ratio is the average horizontal illuminance on two longitudinal strips each adjacent to the two edges of the carriageway and lying off the carriageway divided by the average horizontal illuminance on two longitudinal strips each adjacent to the two edges of the carriageway but lying on the carriageway. The width of all four strips shall be equal to 5 m, or half the width of carriageway, or the width of the unobstructed strip lying off the carriageway, whichever is the least. For dual carriageways, both carriageways together are treated as a single carriageway unless they are separated by more than 10 m.

The average illuminance on the strips on and adjacent to the carriageway should be determined by the same procedure, or mathematically equivalent procedure, as used for determining the average illuminance of the footpath.

Practical implications

All the changes between CIE 30.2 and CIE 140 have an influence on the various solutions for street lighting installations.

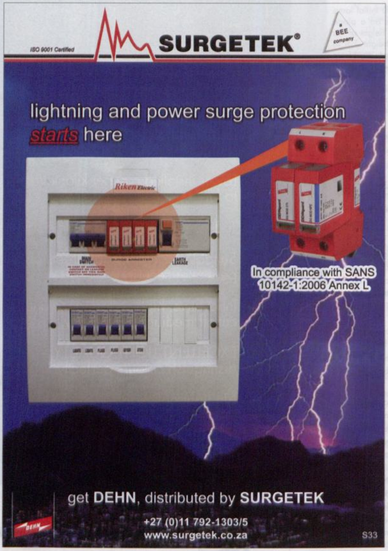
It has been found that the spacing between poles to achieve the required lighting levels, generally have become shorter with the application of CIE 140. End users will now find that the spacing is 5 - 10% less than what was achieved with the old CIE 30.2 method, with the result that quantity and cost, will generally increase by 5 - 10% per kilometre of road illuminated.

For the uninformed, their first response may be that the implementation of CIE 140 is going to cost the taxpayer more for new street lighting installations. However, we must never forget that the whole purpose of street lighting is to ensure that motorists can negotiate roads safely and comfortably and this can only happen when roads are properly illuminated. The whole purpose of CIE 140 is to utilize the experience gained over all these years so that the correct amount of illumination is applied on the road surface to indeed make it safer for motorists.

Street lighting software

The SABS in 1991-1992 commissioned a supplier to write a street lighting program which end users such as municipalities, and suppliers of lighting equipment could use to calculate the spacing between poles to achieve the required lighting level. This program, fondly referred to as the "SABS 098 program" is a DOS based program and the CIE standard street lighting program which appears as a Fortran computer code listing in the CIE 30.2 document, was used as the source code for this new program.

Although there is no reference to the SABS 098 program in SANS 10098-1, it has been the benchmark of street lighting designs with computer software, as it is referred to in ARP 035. Because of the revisions to ARP 035, this program will no longer be suitable to do street lighting calculations; hence all users will now have to switch to some type of commercial software to do calculations. There is a wide choice of such programs: Relux, Dialux, Ulysse, AGI32, Cophos, Lighting Reality, to name but a few. The only proviso is that the software must be able to carry out calculations according to the CIE 140 method, and that the results produced by the program must have been tested by an independent authority to confirm that the calculations are accurate.



Conclusion

The method of doing calculations as per CIE 30.2 is now obsolete and has been superseded by the methods of CIE 140, which contributes to the assurance that the average luminance as observed by a motorist is correct and that the street lighting installation will promote safety and comfort.

Spacing between poles to achieve certain lighting levels will now generally be shorter with a corresponding increase in the "per kilometre" cost of street lighting.

The traditional software such as the SABS 098 program that has been used since 1992 to carry out street lighting calculations is now obsolete and will have to be replaced by commercial software which will do calculations as per the method in CIE 140.

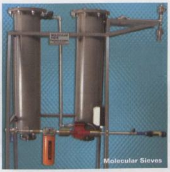
References

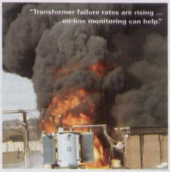
[1] SANS 10098-1: Public Lighting Part 1: The lighting of public thoroughfares.

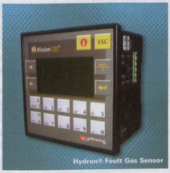
[2] ARP035: Guidelines for the installation and maintenance of street lighting.

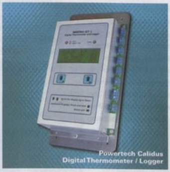
[3] R-TECH (SCHREDER): Presentations on CIE 140.

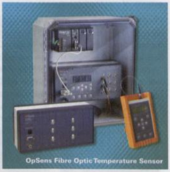
Contact Murray Cronje, Beka, Tel 011 238-0132, cronjem@beka.co.za Δ











An Integrated Approach to Transformer Longevity

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Effective transformer condition assessment

by Luwendran Moodley, Doble Engineering Africa

This paper details a novel approach to transformer condition assessment. This method has proven itself for many years in very large utilities throughout the world. The implementation of this two phase approach is discussed in detail.

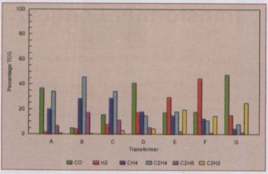
The catastrophic failure and poor performance of transformers is becoming a constant grim reality in the life of Maintenance Engineers and Asset Managers in South Africa. Most of which are left powerless in this struggle due to financial constraints imposed upon them when it comes to the huge capital investment that is required to replace a power transformer and the ever dwindling shortage of highly technical staff. Further to this is the ever increasing delivery time for power transformers. So the message is clear "Make do with what you got and implement a long term replacement exercise". The question still in the minds of Maintenance Engineers and Asset Managers is "How do I do this if I do not know the condition of my transformer?" The answer is effective condition assessment.

Transformer condition assessment

What we know about transformers is that their life expectancy can vary from a few cycles (ms) to more than fifty years. This fact is interesting but not very useful to an engineer responsible for a given network.

What we need to know is the life expectancy of a particular transformer in a given network. This fact is interesting and very useful. This is the essence of condition assessment.

Effective condition assessment is not just testing a transformer and reproducing the test results nor is it diagnosing the cause of a failure after the transformer has failed. Cigré Working Group on Life Management Techniques for Power Transformers has defined condition assessment as `A comprehensive assessment of the condition of a transformer taking into account all relevant information eg. Design information, service history, operational problems, and results of condition monitoring and other chemical and electrical tests". This is an excellent definition that encompasses all aspects of the transformer's life. This model has been successfully implemented in a number of utilities worldwide. However, can effective condition assessment be implemented in utilities with little to no information?



A: Core bolt fault
B: Core and frame to earth circulating currents
C: Winding inter-stand fault
D: Winding shorted turns
E: Winding phase to earth fault
F: Winding tracking fault
G: Winding clamping bolt sparking fault

Fig. 1: DGA signatures for faulty transformers.

By using Doble's two phase process for condition assessment, utilities with little documented information can enjoy the benefits of a comprehensive condition assessment on all types of transformers on the network.

Doble's condition assessment

Doble's condition assessment program is a two phase process. Both steps include proprietary risk scoring system and combine analysis of individual units and FMMAA analysis (family/make/model/ application/ age) of similar designs with similar operating conditions and age. FMMAA analysis is based on existing Doble's equipment performance database with test results and equipment failure and trouble data collected from Doble's customers over more than 40 years.

Phase one

This phase is applied to all units in the network and does not require the units to be removed from service. Phase one of assessment is a "scanning" approach and is more appropriate as a low cost assessment and step to provide "initial" risk assessment and ranking of transformers in a network. This should identify the group of units that are in a sound condition and at a low risk due to their technical condition. The remainder, those identified as higher risk can then be selected for more detailed "Phase Two" investigation, as identified in the following section.

The first step is essentially a review of available information. These include as much as possible of the following:

Step 1: Basic nameplate information from transformer and tapchanger.

All information related to the transformer's manufacturer, vintage, serial number design, ratings, BIL, fault level, impedance, cooling system etc must be captured. From this information design related issues with transformers, service advisories from manufacturers, reports of failure on similar designs, pattern of failure on similar designs can be identified. The above can be obtained from Doble's database with test results (25 million results) and equipment failure data collected for over 40 years.

Step 2: External visual inspection

A visual inspection is conducted on the following:

- *Plinth:* check for cracks or deterioration, anchor bolts missing or rusty, evidence of oil leaks, ground leads or connectors oxidised/ tight etc.
- *Tank:* paint peeling and rust, signs of internal deformation or overheating, oil leaks, loose or missing nuts, bolts, or washers, record liquid level in main tank or any conservator tank, inspect liquid level gauges and wiring, inspect pressure relay and pressure relief device and wiring etc.
- *Cooling system:* paint peeling and rust, oil leaks, inspect pumps and wiring, inspect fans and wiring, inspect radiators for cleanliness, etc
- *Temperature reading:* record temperatures, record position of maximum pointers, inspect temperature sensors and wiring, etc
- *Marshalling kiosk:* inspect external for paint peeling and rust, inspect interior for water ingress and rust, heater operating, inspect breakers, contactors, terminals, wiring, etc.

Dissolved gas (DGA)	Detection of incepted faults - IEEE, IEC, etc
Furfuraldehyde FFA	Paper insulation degradation - Chendon relation to DP
Moisture in oil	Insulation dryness
Breakdown voltage	Dielectric integrity
Acidity	Ageing and sludge
Interfacial tension	Ageing, sludge and contamination

Table 1: Tests and what they determine.

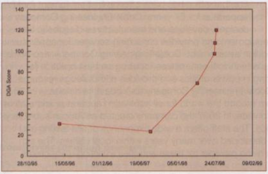


Fig. 2: DGA score for core earth fault.

- *Tapchanger:* paint peeling and rust, signs of internal deformation or overheating, oil leaks, loose or missing nuts, bolts, or washers, record liquid level, inspect pressure relay and pressure relief device and wiring, record number of operations, inspect tap changer mechanism, etc.
- *Bushing:* chipped or broken sheds, oil leaks, oil levels, inspect connections, etc.
- *Surge arrester:* chipped or broken sheds, inspect connections, etc.

Step 3: Review of all available documentation

- *Factory test report:* used to compare with current test results and operating ability.
- *Purchasing specification:* used to compare to current manufacturing standards.
- *Tests results (electrical and oil):* current data can be compared to Doble database for industry norms.
- *Failure reports:* indicates the rate of aging, availability and performance.
- *Maintenance practices:* what are you doing?
- *Major modifications or rebuild:* indicates the rate of aging generally expected.
- *Substation fault level:* changes in fault rating.
- *Loading:* used to calculate loss of life.

Step 4: Additional non invasive tests

- Oil tests (main tank): a sample would be taken and analysed with the standard methods. The table below gives a few standard oil tests.
- *Doble DGA scoring system:* Doble has developed an algorithm to mimic the key gas response and gives a single number to track the change in pattern. This method uses the key gas method to present DGA used by IEEE method. The relative proportions of the si combustible gases CO, H_2, CH_4, C2H4, C_2H_6 and C_2H_2 are displayed as a bar chart to illustrate the gas signature. The novel aspect of the approach proposed here is that this method is used to investigate and illustrate the clear difference that exists between 'normal' and 'abnormal' results. By contrast, in the IEEE Guide four examples of faults are given, but there is no guidance on what a normal result would look like. The DGA score reflects the seriousness of the signature. DGA results for normal transformers would be expected to return a score of no more than about 30, whereas a core circulating current would rate about 60 and more serious problems would score around 100.

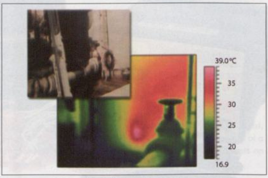


Fig. 3: IR scan of a hot spot.

Fig. 4: UHR scan.

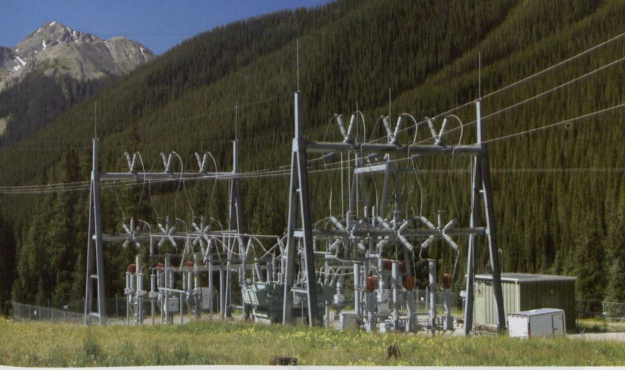
- Infra red scan: infra red will indicate external joint issues, bushing tap problems, oil levels in bushings and radiators, blockages in radiators, fan-function it can also indicate tank heating from stray flux, or frame tank circulating current. The figure below illustrates an internal tank hot spot.
- UH RIF scan: UHF interference surveys have been undertaken for the last 20 years in UK. Corona will produce interference up to a few 10s of MHz, and surface discharge in contamination on bushings has a spectrum extending to 200 MHz. However, when internal partial discharge occurs the spectrum extends to 1 GHz. Scanning 300 600 MHz has proven effective in identifying a range of substation faults, including discharge at faulty bushing taps and within the main tank itself. The figure below illustrates a UHF scan with discharge activity on one tap position only.

Step 5: Consultation with staff

Consultation with all staff involved in the life management of transformers forms an integral part of this process in that this is a great source of information that has not been documented.

Phase 1: assessment of technical condition

Once all the information has been gathered and the additional non invasive tests performed the transformers can then be scored based on its condition. The Doble scoring system is given in Table 2.



Condition	Definition	Score
New	No damage	1
Normal ageing	Reasonable for age	3
Aged	Some ageing - in need of some monitoring	10
Suspect	Identified ageing, significant risk for failure	30
Unacceptable	Unacceptable ageing	100

Table 2:

Transformers condition is further divided in design, dielectric, thermal and mechanical, and scored to a Doble scoring system. A typical assessment of the technical condition is given in Fig. 5, 6 7 and 8.

All units have been assessed in terms of design groups with problems, overall condition, thermal and dielectric condition. Also included in the assessment is a score for the design group, tap changer, bushings and surge arresters. Each aspect has its own score a number between 1 and 100. Even with summation any aspect with a 100 score will be carried through and easily recognised. The results are assessed using this sum of the numerical scoring system and it is this sum that determines the position in the "league table" and summarised using a red-green colour traffic light code. It should be emphasised that the score is not permanent it's a "live" document, reviewed each month as new evidence is presented.

Outcomes of phase one

Once this process is completed the following is made evident:

- Establishment of an asset register.
- Design weakness.
- High risk transformers in terms of the dielectric and thermal condition.
- High risk transformers in terms of the environment, staff and third parties.

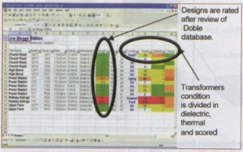


Fig. 5: Typical assessment of the technical condition.

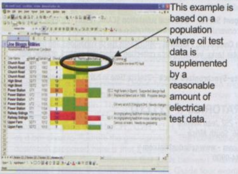


Fig. 6: Typical assessment of the technical condition.

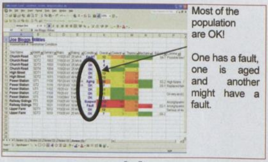


Fig. 7:

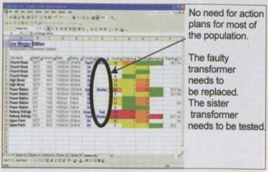


Fig. 8:

All the transformers that fall in the above category would then be considered for phase two of the condition assessment process.

Phase 2

This phase is applied only to units that have been identified as high risk from Phase 1.

This phase is a comprehensive analysis of the transformer, and requires off line testing. The standard off line tests are as follows:

- Tan δ and capacitance - windings and bushings
- Sweep frequency response analysis
- Leakage reactance
- Insulation resistance
- Winding resistance
- Exciting current
- Ratio test

Note: Explanation on the above electrical tests is given in Appendix A.

Resoring the technical condition

Once all the off line tests are performed the technical condition of

Unit level	Condition	Weighting	Risk
Thermal	10	0,8	8
Dielectric	30	0,8	24
Mechanical	3	0,6	1,8
Core	10	0,4	4
Oil	3	0,8	2,4
Tank	3	0,2	2
Bushings	3	0,8	2,4
Topchanger	3	0,6	1,8

Table 3:

each transformer can be restored with greater detail. This is shown in Table 3.

The restoring now includes the mechanical condition of the transformer. With the final scoring for the condition of the transformer now in place a weighting for each unit level can be assigned. From this a risk of each unit level can be determined. A total risk of each transformer can then be calculated.

Outcomes of Phase 2

Once the restoring has been completed the following is made evident:

- High risk transformers in terms of the dielectric, thermal and mechanical condition.
- More accurate overall condition as a result of the off line tests.
- An action plan in terms of units that require replacement, repair and monitor.
- The transformer's risk.

The results of phase two are merely added to the existing assessment. A typical layout is shown below.

Conclusion

Transformer condition assessment program can be effectively introduced by using this two phase approach. This method of condition assessment can be implemented irrespective of the amount of information. It allows utilities to finally have answers to the following situations:

- When to have maintenance outages. How to respond to a protection trip.
- To know capability to increase transformer rating.
- To know when to replace (5, 10, 15 year) transformers

An added advantage is that this method forces the utilities to make the bold move to condition based maintenance. A further advantage is the risk assessment and residual life can finally be achieved through sound engineering principles.

References

[1] A Wilson: "Impact of technical condition in utilitsation of power transformers", *Proceedings of the 2002 International Conference of Doble Clients*, Boston, MA

[2] J A Lapworth: "A scoring system for integrating dissolved gas analysis results into a life management process for power transformers" *Proceedings of the 2002 International Conference of Doble Clients*, Boston, MA

[3] A Wilson A, J A Lapworth: *"Asset Health Review to Manage Remaining Life"* IEEE PES Power Africa, Johannesburg, South Africa, 2007

[4] CIGRE Working Group 12.18: *"Life Management of Power Transformers"*.

Appendix A: electrical testing of transformers

Tan δ and capacitance windings

Tan δ (dissipation factor) is merely the tangent of the loss angle that is created by the capacitive and resistive current that is present in a dielectric medium. Measurements are typically made between the high voltage winding to ground, between the high voltage and low voltage winding and between the low voltage winding to ground. This measurement method allows assessment of individual winding hence focusing on the area of deterioration. As Tan δ is dependent on temperature the measure values are normalised to 20°C by applying a correct factor.

Tan δ is an evaluation of the quality of the insulation and is size independent. Tan δ has proven to be effective in the detection of the following problems in transformers of all sizes:

- Moisture
- Carbonisation of insulation
- Contamination of oil by dissolved materials or conducting particles
- Improperly grounded core

Winding capacitance on the other hand evaluates the physical makeup of an insulation system which is size dependent. Capacitance measurements have proven over the year to be very effective if reference results are available. Changes in the region of 10% would normally indicate extreme winding movement. However, this method of detecting winding movement is not as effective as sweep frequency response analysis (Fig. 10).

Tan δ and capacitance - bushings

If bushings are equipped with a test tap two, measurements can be performed which are a C_1 and a C_2. The C_1 test measures the condition of the main bushing insulation to the test tap. The C_2 test measures the condition of the test tap insulation to ground and core. Insulation between tapped layer and bushing ground sleeve.

The C_1 and C_2 tests are effective in identifying the following defects:

- Moisture ingress
- Carbonisation of insulation
- Short circuited condenser layers
- Contamination of oil by dissolved materials or conducting particles
- Open circuits such as break in the band between the ground and mounting flange

Exciting currents

The exciting current is, for practical purposes the current that flows when the winding of a transformer is energised under no load conditions.

The exciting current creates a magnetic flux in the core, and the flux in turn induces a voltage in the energised winding that opposes the applied voltage. Consequently, the exciting current is small, usually only a few percent of the rated load current of the winding. The exciting current of a transformer is made of three components:

- A magnetising part (Im) required to build the magnetic field in the transformer core. It is often referred to as the magnetising current.
- A resistive part (I_r) required to supply all the losses in the transformer at no load.
- A capacitive part (I_c) required to build the electrical field in the insulation of the transformer.

This is a single phase test that was introduced in North America as a diagnostic tool in 1967 and today is part of standard insulation tests in the field. The single-phase exciting-current test is useful in locating problems such as defects in the magnetic core structure, failures in the turn to turn insulation, or problems in the tap changing device. These conditions result in a change of the effective reluctance of the magnetic circuit, which consequently affects the current required to force a given flux through the core.

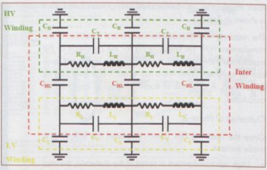


Fig. 9: Simplified equivalent circuit with lumped RLC components.

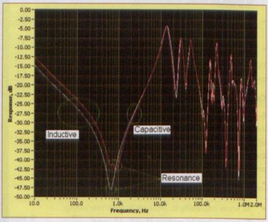


Fig. 10: Frequency response of a sound transformer.

The diagnostic analysis of exciting current test results is based largely on pattern recognition.

Ratio test

Doble's method uses a high voltage (10 kV) and involves measuring the capacitance of the capacitor by itself and the apparent capacitance when it is connected across the low voltage winding. The ratio of these to capacitance yields the turns ratio of the transformer. The greatest advantage of this high voltage test method is that high resistance areas can be overcome, where as low voltage test sets might show such an area as an open circuit. Ratio test has been used very successfully over a number of years for the following:

- Confirm ratios are within 0,5% of nameplate data
- Detect short circuited turn to turn
- Detect open circuit windings
- Confirm tap lead connections

Sweep frequency response analysis (SFRA)

The loss of mechanical integrity in the form of winding deformation and core displacement in power transformers can be attributed to the large electromechanical forces due to fault currents, winding shrinkage causing the release of the clamping pressure and during transformer transportation and relocation. This winding deformation and core displacement, if not detected early, will typically manifest into a dielectric or thermal fault. This type of fault is irreversible with the

only remedy been rewinding of the phase or a complete replacement of the transformer. It is therefore imperative to check the mechanical integrity of aging transformers periodically and particularly after a short circuit event to provide early warning of impending failure. Hence an early warning detection technique of such a phenomena is essential. Frequency response analysis is recognised, as being the most sensitive diagnostic tool to detect even minor winding movement and core displacement.

The transformer is considered to be a complex network of RLC components. The contributions to this complex mesh of RLC circuit are from the resistance of the copper winding; inductance of winding coils and capacitance from the insulation layers between coils, between winding, between winding and core, between core and tank, between tank and winding, etc. However, a simplified equivalent circuit with lumped RLC components as illustrated in Fig. 9 can be used to accurately explain the principle of frequency response.

Any form of physical damage to the transformer results in changes to this RLC network. These changes are what we are looking for and employ frequency response to highlight these small changes in the RLC network within the transformer. Frequency response is performed by applying a low voltage signal of varying frequencies to the transformer windings and measuring both the input and output signals. The ratio of these two signals gives the required response. This ratio is called the transfer function of the transformer from which both the magnitude and phase can be obtained. For different frequencies the RLC network offers different impedance paths. Hence, the transfer function at each frequency is a measure of the effective impedance of the RLC network of the transformer. Any geometrical deformation changes the RLC network, which in turn changes the transfer function at different frequencies and hence highlights the area of concern.

Impedance at different frequencies relate to the resistance, capacitance and inductance of a transformer. The resistance is related to the physical construction of the winding (shorted turns, core earth etc.) and results in the vertical shift (dB axis) of the response. The capacitance and inductance are related to the geometry of the winding (deformation) and results in a horizontal shift or frequency shift.

At the lower frequency range the capacitance of the transformer can be disregarded and the response is purely inductive. At these frequencies the inductance of the magnetic circuit dominates. There is a significant difference in the responses between the outer two phases and the centre phase at this frequency range. This is due to the flux paths of the core. The centre phase has two flux paths of equal reluctance and the outer phase has two flux paths of different reluctance. As a result the outer phases has two resonance points as compared to the centre phase that has just one resonance point. This also accounts for the difference in the starting dB values.

At higher frequency ranges the response looks very confusing and complex as a result of the numerous resonance points. At this frequency range the winding inductance dominates with the magnetic circuit effectively screened. Hence, the winding responses are less dependent on the magnetic circuit, which makes the measurement more sensitive to winding deformation. At the highest frequencies the inductance can be disregarded and the response is effectively capacitive. Δ

Improving the performance and reliability of power system transformers

by Dr. Michael Kruger, Alexander Kraetge, Omicron Electronics, and Alexander Dierks, Alectrix

Due to ever increasing pressure to reduce costs, the power industry is forced to keep old power facilities in operation as long as possible. In most European countries, about one third of the transformers are older than 30 years.

With the advancing age of transformers, a regular check of the operating conditions becomes more and more important. Dissolved gas analysis (DGA) is a proven and meaningful method such that if increased proportions of hydrocarbon gases are found in the oil, the fault must be located as soon as possible. Hence important preventative maintenance can be performed in time to avoid an unexpected total failure (Fig. 1) [1].

The most frequent sources of faults are the tap changers, bushings, the paper oil insulation and the accessory equipment (Fig. 2) [2].

In order to find out the reason for high gas values, further tests have to be performed for the transformer. Common test methods are:

- Static and dynamic winding resistance measurement.
- On load tap changer (OLTC) test.
- Turns ratio and excitation current measurement.
- Measurement of leakage reactance and FRSL
- Sweep frequency response analysis (SFRA) measurement.
- Frequency dependant capacitance and dissipation factor measurement.
- Partial discharge (PD) measurement.
- Di-electric response analysis.

Winding resistance measurement and OLTC test

Winding resistances are measured in the field to check for loose connections, broken strands and high contact resistance in tap changers.

Static winding resistance measurement on a 220 kV/110 kV/10kV/100 MVA transformer

The transformer under test was found to have conspicuously high quantities of gas in the oil, from which the conclusion was drawn of inner overheating. Except for the middle tap all taps showed a significant increase compared to the original measured values. The differences are more than 10% or, in absolute values, up to 70 mΩ (Fig. 3).

The deviations between switching upwards and switching downwards are likewise clearly significant. This indicates high contact resistances caused by the contacts of the tap selector switches. No silver plated contacts were used and the copper contact surface was now coated by oil carbon. After a full maintenance of the tap selector, no significant difference to the values measured at the factory in 1954 could be observed (Fig. 4). To examine the results in more detail, it is recommended to view the difference between "UP" and "DOWN" values (Fig. 5). The difference before contact maintenance was up to 30 mΩ (or 5%) and after it was below 1 mΩ (or 0,18%).

Dynamic behaviour of the diverter switch

To date, only the static behaviour of the contact resistances has been taken into account in maintenance testing. With a dynamic resistance measurement, the dynamic behaviour of the diverter switch can be analysed (Fig. 6).

Comparison to "fingerprint" results, which were taken when the item was in a known (good) condition and to the other phases, allows for an efficient analysis. A glitch detector measures

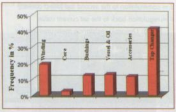


Fig. 2: Sources of transformer faults [2]

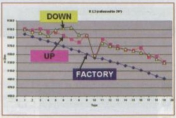


Fig. 3: Winding resistance measurement H1-H0

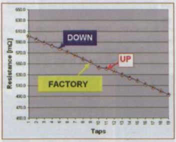


Fig. 4: Resistance after maintenance.

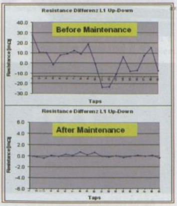
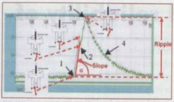


Fig. 5: Difference "UP" - "DOWN".


Fig. 1: Transformer fault due to a defective bushing.



1 = diverter switch commutes from the first tap to the first commutation resistor

2 = the second commutation resistor is switched in parallel

3 = commutation to the second tap (direct contact)

4 = regulation back to the set current value

Fig. 6: Dynamic resistance measurement for analysis of the diverter switch.

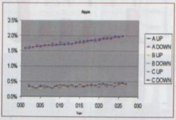


Fig. 7: Ripple measurement of a good diverter switch.

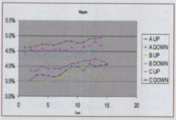


Fig. 8: Ripple measurement of an aged diverter switch.

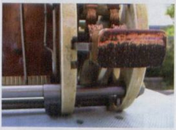


Fig. 9: Aged diverter switch contacts.

Fig. 10: Impedance measurements on defective transformer.

the peak of the ripple (I_{max} - I_{min}) and the slope (di/dt) of the measuring current, as these are important criteria for correct switching. If the switching process is interrupted, even for less than 500 µs, the ripple and the slope of the current changes dramatically.

For tap changers in good condition the ripple and slope measurements for all three phases tapping UP should be similar and those for tapping DOWN should also be similar. Fig. 7 shows a ripple measurement for a diverter switch in a good condition

Fig. 8 shows the ripple measurements for the three phases of an aged diverter switch. The differences of the ripple values were due to the advanced aging of the diverter switch contacts (Fig. 9), which proves the sensitivity of the measurement principle to changes of the contact surface.

Diagnosis of a defective transformer

A 220 kV/110 kV/10 kV 100 MVA transformer was damaged by a marten. It short circuited the 10 kV side and caused a through fault current of 54 kA. Although the transformer was switched off within 100 ms, Phase A of the 10 kV winding was short circuited to the core.

First off the ratio was measured (Fig. 10). A large difference of approximately 20% indicated a failure with 20% of the turns. The excitation current of phase A was 340 mA whereas the excitation current of the remaining phases was 10 mA.

Leakage reactance and FRSL measurement

As a second test the leakage inductance was measured. The used test instrument has a power amplifier which allows measurements from 15 to 400 Hz (Fig. 10) [3].

Fig. 11 shows that for low frequencies the leakage inductance of the faulty phase A is much higher than for phase B and C. For high frequencies the values are similar.

For the measurement of the frequency response of stray losses (FRSL) the resistive part of the short circuit impedance Rsc is measured from 15 to 400 Hz. The FRSL is an indicator for short circuited parallel strands of transposed conductors. Fig. 12 shows the comparison of the three phases. The A phase shows much higher losses.

SFRA measurement

Also the measurement of the sweep frequency response analysis (SFRA) showed a clear difference between phase A and the phases B and C.

Conclusions of defective transformer

The conclusion was that the faulty winding was interrupted and parts of the winding were contacting the core. This resulted in a part

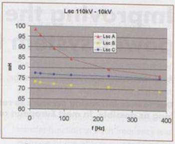


Fig. 11: Leakage inductance L_{sc} = f(f).

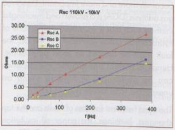


Fig. 12: FRSL measurement R_{sc} = f(f).

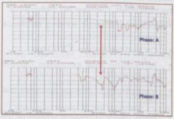


Fig. 13: SFRA measurement.

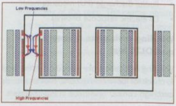


Fig. 14: Model of the defective winding.

Fig.15: Defective winding with interrupted conductors.

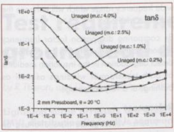


Fig.16: Losses in Pressboard = f(f, water content).

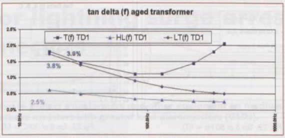


Fig.17: Losses in different insulation gaps.

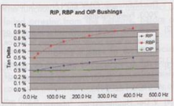


Fig. 18: RIP, RBP and OIP bushings in good condition.

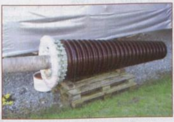


Fig. 19: 245 kV RIP bushing stored outside.

Fig. 20: Tan δ of a 245 kV RIP bushing stored outside.

of the secondary short circuit current flowing through the core. With higher frequencies the current was displaced to the core surface due to the skin effect (Fig. 14).

Opening of the defective transformer

The transformer was opened three months later. Fig. 15 shows the totally damaged 10 kV winding. The interruption of conductors can be seen clearly.

Capacitance and dissipation factor measurement

In the past, the dissipation or power factor was measured at line frequency. Nowadays power amplifiers enable measurements in a wide frequency range.

In [4] the dissipation factor (DF) of pressboard was measured at different frequencies (Fig. 16). The four curves show the tan δ for water contents of 0,2%, 1 %, 2,5% and 4%. A transformer contains a complicated insulation system. High and low voltage windings have to be insulated to tank and core and against each other. The dissipation factor is a good indicator of the oil paper insulation quality of the single gaps. The dissipation factor increases with degradation of oil, water content and contamination with carbon and other particles.

Fig. 17 shows a DF measurement of different insulation gaps: HV to LV winding (HL), LV to TV winding (LT) and TV winding to the core (T). It is obvious that the HL gap has the lowest water content (2,5%) in the paper and the lowest dissipation factor at low frequencies, whereas LT and T have higher water contents (3,8 and 3,9%) and higher dissipation factors. The TV winding is not in use and hence has a lower temperature during service. It can be deduced that the water in the insulation paper is not homogenously distributed.

C tan δ measurement on high voltage bushings

The high voltage bushings are critical components of the power transformer and capacitive high voltage bushings inparticular need care and regular tests to avoid sudden failures. These bushings have a measurement tap point at their base and both the capacitance between this tap and the inner conductor (normally called C1) and the capacitance between the tap and ground (normally called C2) are measured. An increase of C1 indicates partial breakdowns of the internal layers. To determine bushing losses, dissipation factor tests are performed. Most of bushing failures may be attributed to moisture ingress. As already shown with the winding to winding insulation, analysis of bushing insulation is much more detailed when frequency scans are performed. Fig. 18 shows the dissipation factor of resin impregnated paper (RIP), resin bonded paper (RBP) and oil impregnated paper (OIP) bushings in good condition. The frequency response is rather flat over frequency and shows low values for the dissipation factor particularly at low frequencies.

Fig.21: 33 kV OIP bushings.

In Fig. 19 a RIP bushing is shown, which was stored outside without any protection. The first measurement was made directly after the bushing was removed from the transformer, the second measurement after three-and-a half months and a third measurement after more than seven months.

Fig. 20 shows a consistent increase of the dissipation factor as the bushing was subjected to ambient humidity and rain. Also the minimum of the curve has shifted to higher frequencies with increased humidity.

In Fig. 21 33 kV OIP bushings are shown. The bushings were dismounted from the transformer because their dissipation factor was very high, particularly at high temperatures. Fig. 22 shows the DF of dry and wet OIP bushings at 50 Hz for different water contents as a function of temperature [5].

The tests show and increased sensitivity of the dissipation factor measurements at high temperatures compared to ambient temperature. However, in the field it is not so easy to heat up bushings before measurement.

In a second test the dissipation factor for a set of replaced bushings and a set of new ones was measured at 30°C, but this time at different frequencies. The replaced bushings show high tan δ values particularly at low frequencies. The new bushings have flat frequency responses with low losses also at low frequencies. These tests indicated an increased sensitivity at low frequencies, which can be realised easier than the 50 Hz measurement at high temperatures.

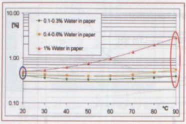


Fig. 22: Tan δ at 50 Hz = f(T).

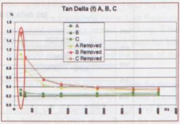


Fig.23: Tan δ at 30°C = f(f).

The examples show, that the measurement of the dissipation factor over a wide frequency range enable for a better diagnosis of the insulation compared to measurements at power frequency only. Particularly the low frequency range makes the measurement much more sensitive for water contents in the insulation mediums.

Summary

With advancing age transformers require regular checks of the operating conditions and these become increasingly important. The analysis of the gas in oil is a well proven method of analysis but must be complemented by efforts to locate any faults indicated by excess hydrocarbon gases in the oil. In this way important maintenance can be performed in time to avoid sudden and/or total failure.

Possible fault locations can be investigated successfully by performing electrical tests such as static and dynamic winding resistance, winding ratio and excitation current measurements, leakage reactance and frequency response of stray losses measurements as well as sweep frequency response analysis. Modern power amplifiers enable measurements in a wide frequency range which will enhance the diagnosis methods.

By comparing dissipation factor frequency response curves to fingerprints it is possible to detect degradation in the insulation mediums of both transformer windings as well as bushings at a very early stage.

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Test requirements for lightning surge arrester ground lead disconnectors

by R Theron, and Dr. H Geldenhuys, Eskom

Lightning surge arresters are widely used by utilities to protect transformers and other equipment on medium voltage (MV) distribution lines. It is common practice to fit these arresters with ground lead disconnectors (GLDs).

The function of the GLD is to disconnect a failed arrester from the network, before a permanent earth fault occurs.

International specifications tend to focus mainly on the arrester, neglecting the GLD. The specified requirements do not adequately cover the performance, duty and reliability of the GLDs.

Specific problems experienced by Eskom in recent years include: lack of co-ordination with earth fault protection settings, operation of the GLD when the arrester is not damaged, failure of the GLD to operate when it is supposed to operate, as well as deterioration of the GLD due to weathering of the unit over time.

These problems had significant impact on Eskom's reliability of supply. Eskom was therefore compelled to reassess the international test requirements for GLDs. Significant deficiencies were identified and six additional test requirements have been developed by Eskom to ensure that future products will be suitable for application on the Eskom network.

The paper starts off with a discussion on the basic operation of a GLD and the international test requirements for GLDs. Eskom's recent field experiences with GLD's are then examined and the subsequent changes to the type test requirements are discussed.

Basic workings of a GLD

The most commonly used GLD design consists of a spark gap, a resistor and a blank cartridge. The basic circuit diagram of such a GLD is indicated in Fig. 1.

The resistor provides a path through the GLD for the arrester's leakage current. Most designs use standard, 22 kΩ, film resistors (i.e. the type used in electronic circuits). The cartridge is a standard 0,22, blank cartridge. The blank cartridge will ignite when enough heat is generated in the GLD. The resulting explosion provides the mechanical force that is required to disconnect the earth connection from the arrester.

To explain the operation of a GLD it is necessary to look at the following four conditions:

Healthy arrester under power frequency conditions

The GLD resistor is connected in series with the arrester's metal oxide varistor (MOV) blocks which result in a voltage divider circuit. Under normal power frequency conditions, the resistance of the MOV blocks is very high in comparison to the resistance of the resistor. The majority of the system voltage is therefore dropped across the MOVs and the voltage across the resistor remains below the flashover voltage of the spark gap. Leakage current in the order of 300 μA will constantly flow through the MOVs, the resistor and the cartridge. The associated energy is however too low to generate enough heat to ignite the cartridge. The arrester and GLD can therefore remain in this state indefinitely.

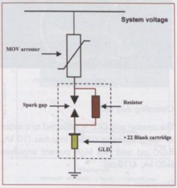

Fig. 1: Circuit diagram of a typical GLD.

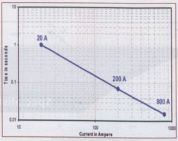

Fig. 2: GLD operating curve.

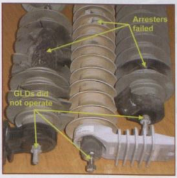

Fig. 3: The GLDs did not operate when the arresters failed.

Failed arrester under power frequency conditions

If a power frequency overvoltage condition occurs that exceeds the temporary overvoltage capability of the arrester, the MOVs will fail. The MOVs normally fail short-circuit, which means that the full system voltage will suddenly appear across the resistor and spark gap. The spark gap will therefore flash over and the system's earth fault current will flow through the GLD. Enough heat will be generated instantly and will ignite the cartridge, thereby disconnecting the earth tail from the arrester. The arrester and the GLD will be permanently damaged and will have to be replaced as soon as possible.

Healthy arrester under transient conditions

When the arrester is subjected to a transient overvoltage, as in the case of a lightning surge, the resistance of the MOV's will temporarily reduce to a very low value in comparison to the resistance of the resistor. The voltage across the resistor and the spark gap will rise and the spark gap will flashover. Surge current will flow through the arrester and the cartridge for a short time. Once the overvoltage condition passes the MOV resistance returns to a very high value again, the voltage across the gap reduces and the arc across the gap is quenched. Not enough heat is generated to ignite the cartridge due to the very short duration during which the surge current flows through the GLD. The arrester and GLD therefore return, undamaged, to the same state in which it was before the surge condition.

Failed arrester under transient conditions

If the surge energy exceeds the energy capability of the arresters, the MOV will fail. The surge current will be followed by power frequency follow-through current. Enough heat will be generated instantly to ignite the cartridge, thereby disconnecting the earth tail from the arrester. The arrester and the GLD will be permanently damaged and will have to be replaced as soon as possible.

International specifications

The two main international specifications for surge arresters are IEC 60099-4 [1] and IEEE C62.11 [2]. The following test requirements are specified in the IEC specification, the IEEE requirements are however almost identical.

Time versus current curve test

Power frequency voltage is applied across the GLD until it operates. The duration to first movement of the GLD is recorded. This procedure is conducted at three current levels: 20 A, 200 A and 800 A.

The recorded operating time at each current level is plotted to provide the GLD's operating curve, as indicated in Fig. 2.

Long duration current impulse test

The arrester and GLD are subjected to a series of eighteen long duration current impulses (2000 μs square wave, peak current > 250 A).

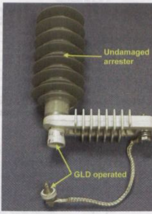

Fig. 4: Premature GLD operation.

Operating duty test

The arrester and GLD is subjected to a series of twenty lightning current impulses (10 kA, 8/20 μs) and two high current impulses (100 kA, 4/10 μs).

Discussion

The purpose of the first test is to establish the operating time of the GLD at different current levels. The aim of the second and third tests is to simulate transient conditions that the arrester and GLD could be subjected to when in service. The arrester is required to withstand these impulses. The GLD should also withstand these impulses without operating, because the GLD should only operate in the case of an arrester failure.

Field failures

Compliance with the above mentioned test requirements are strictly enforced on all arresters applied on the Eskom network. However, large numbers of GLD maloperations have been reported in recent years.

The majority of these maloperations can be grouped into two categories:

- GLDs that do not operate when the arrester fail, examples are shown in Fig. 3.
- GLDs that are too sensitive, i.e. the GLD operates prematurely on an arrester that is still in a good condition. An example is shown in Fig. 4.

GLDs that fail to operate

The investigation revealed that these maloperations occurred, because the GLD operating curves do not grade with the upstream protection. It was found that a loss of co-ordination can occur between the operating time of the GLD and the sensitive earth fault (SEF) setting at the upstream protection device.

The purpose of the GLD is to remove a failed arrester from the network, before the subsequent earth fault is permanently cleared by upstream protection. The GLD should therefore ensure that an arrester failure does not affect the rest of the network due to a permanent outage. Loss of co-ordination between the GLD and the SEF protection defeats the object, because the upstream breaker clears the earth fault before the GLD can operate.

According to Eskom's settings philosophy for rural feeders [3], SEF pick-up settings are set between 3 A and 6 A. The time-current characteristic is a definite time characteristic with the trip delay set between 3 s and 15 s. A typical SEF setting has a pick-up of 5 A and a trip delay of 5 s. The SEF setting range is illustrated in Fig. 5.

The GLD operating characteristic curves of the arresters that were most commonly used by Eskom at the time are shown in Fig. 5.

According to these operating curves the GLD's of all three makes will operate faster than the SEF element for earth fault currents of 20 A and higher. The GLD operating times below 20 A were however not readily available, because the international specifications only require the test to be conducted at 20 A, 80 A, 200 A and 800 A. The manufacturers were approached to provide operating times at lower currents. These operating points are indicated in Fig. 5 with the 'star' symbols.

Product A grades with the SEF settings in all cases. A straight-line extrapolation (dotted line) suggests that product B will start to lose co-ordination below 4 A. The manufacturer of product C indicated that it will not operate at all for currents below 15 A. These findings correlated well with maloperations that were reported from the field.

Eskom therefore decided to amend the requirements of the time versus current curve test. It is now specified that the GLD operating time must also be recorded at 5 A and it must be faster than 3 s.

The GLD operating curves for products A, B and C, after implementation of the amended requirements, are shown in Fig. 6. The operating times for products B and C are notably faster.

Premature GLD operation

The investigation revealed that the premature GLD operations occurred during lightning storms, predominantly in areas with high lightning ground flash densities. It was therefore necessary to investigate whether the specified type tests adequately simulate the lightning

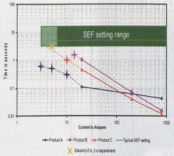

Fig. 5: GLD operating curves.

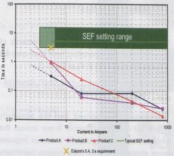

Fig. 6: New GLD operating curves.

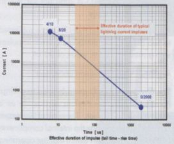

Fig. 7: GLD current impulse test points in accordance with IEC 60099-4.

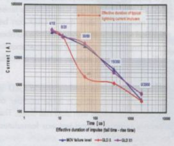

Fig. 8: MOV failure level versus transient operation curve of GLD.

conditions that the arrester will be subjected to on a distribution network.

The effective duration of an impulse is defined as the difference between the tail time and rise time of the impulse, as detailed in clause 8.1. The effective duration of typical lightning impulses [4], [5] is between approximately 30 μs and 120 μs. The effective durations of the three test impulses specified in IEC 60099-4 are however 6 μs, 12 μs and 2000 μs respectively. The differences in the effective impulse current durations are illustrated in Fig. 7.

The effective duration of the standard specified test impulses do not correlate well with the effective duration of typical, natural lightning impulses. The IEC type tests therefore do not provide a good indication of a GLDs withstand capability for typical lightning impulses. Additional current impulse withstand tests with an effective impulse duration of between 30 μs and 120 μs are required.

All the premature GLD operations occurred with one specific make and model of arrester and GLD, dubbed 'product X' for the purpose of this paper. Product X complied fully with all the type test requirements of IEC 60099-4. It was therefore suspected that the operating characteristic of the unit is too sensitive in the zone of typical lightning impulses. The particular arrester and GLD were subsequently subjected to two additional current impulses with 15/350 μs and 30/80 μs wave shapes, the results are illustrated in Fig. 8.

The MOV failure level indicates the amplitudes at which the MOV blocks of arrester X will fail for each of the wave shapes specified by IEC 60099-4, as well as for the two additional wave shapes.

The 'GLD X' curve shows the current impulse withstand values of GLD X and can be described as the transient operating curve of the GLD.

In principle the GLD should only operate once the arrester failed. The MOV failure level of the arrester should therefore be located below, or at least very close to, the transient operating curve of the GLD. It is clear from Fig. 8 that this is not the case, especially in the range of typical lightning impulses. For a 30/80 μs impulse the GLD X will operate at 2 kA, whereas the MOV will only fail at about 30 kA. The GLD is more sensitive than the arrester at these wave shapes, which explains the maloperations that occurred on the network.

Manufacturer X subsequently designed a new less sensitive GLD, GLD X1. The transient operation curve of GLD X1 is also indicated in Figure 8 and it can be seen that it grades well with the MOV failure level of arrester X.

The transient operating characteristics of GLDs X and X1 were also benchmarked against GLDs from other manufacturers that have been successfully utilised on the Eskom network for a number of years. The results for 30/80 μs current impulses are illustrated in Fig. 9.

The withstand value of GLD X was found to be significantly lower than that of products A, B and C. The withstand value of the redesigned GLD X1 is much closer to the other models and is even slightly less sensitive.

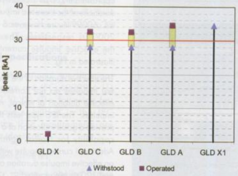

Fig. 9: Benchmarking of current impulse withstand values for a 30/80 µs wave shape.

Eskom's new GLD test requirements

The field failures and investigations that followed brought to light the fact that the requirements of the international specifications for GLDs do not adequately cover performance, duty and reliability of GLDs

The following additional test requirements were therefore added to Eskom's specification for distribution class surge arresters, SCSSCAAN5 [6].

These tests do not only focus on the failure modes that were discussed in the previous two sections. Additional possible failure modes were identified and test requirements were formulated to also cover it.

Three of the main surge arrester manufacturers, on the international market, comply currently with Eskom's amended test requirements.

Time versus current curve test

The GLD operation curve has to grade with the SEF settings. It is therefore specified that in addition to the standard requirements of IEC 60099-4 the operating time shall also be obtained at 5 A and it must be ≤ 3 s.

High lightning duty current impulse withstand test

The investigation proved that the sensitivity of a GLD is not necessarily linear across the whole spectrum of possible transient impulse wave shapes. It is for that reason necessary to ensure that the current impulse withstand capability of the GLD is sufficient for typical lightning wave shapes.

It is therefore specified that GLDs are subjected to two consecutive 30/80 µs current impulses with a minimum peak value of 30 kA.

Repetitive surge withstand ability test

The arrester and GLD are subjected to a large number of impulses over its service life as a result of induced surges. These repetitive surges can erode and damage the internal components of the GLD to such an extent that the operating characteristics of the GLD are altered.

In a paper by Geldenhuys and Theron [7] it is shown that small surges with slow rise times is the most severe duty that a GLD can be subjected to. It is further shown that the number of such impulses that a GLD will experience in its life on the South African network is in the order of a thousand impulses.

A test is required to confirm that a GLD is capable of withstanding a large number of low amplitude surges with slow rise times. The repetitive surge withstand test was formulated for this purpose.

GLDs are subjected to a thousand consecutive voltage impulses. The amplitude of the impulses must exceed the spark over value of the GLD's internal gap by 120%. The impulses must have a virtual front time of 5 µs to 10 µs and the tail time should be long enough to ensure that sparkover occur across the GLD's internal gap. The thousand impulses are applied consecutively with a 50 s to 60 s interval between impulses.

Thermal pre-conditioning and water immersion test

It is critical that the GLD is hermetically sealed for its entire service life. A moisture ingress test is specified in IEC 60099-4, but it is only required on the arrester. The Eskom specification requires that this test also be conducted on the GLD. The aim of this test is to first thermally age the GLD and then to confirm that the GLD remains sealed.

The moisture ingress test consists of three parts; thermal, mechanical pre-conditioning and water immersion. GLDs should be subjected to the thermal preconditioning and water immersion parts of the test. The mechanical part of the test is not required on the GLD.

The GLD is subjected to specific thermal variations consisting of two 48 hour cycles of heating and cooling, conducted in air. The thermal pre-conditioned samples are then subjected to the water immersion test.

The water immersion test essentially requires that the GLD is boiled in salt water for 42 hours and thereafter cut open to verify if any moisture ingress occurred

GLD resistance measurements

The pass criteria in the IEC specification simply require that the GLD does not operate when subjected to the current impulse tests. It is however possible that the GLD's internal resistor failed short-circuit during the test. The spark gap will therefore be permanently bridged-out and the GLD will never operate.

The Eskom specification consequently specifies that the resistance of the GLD be measured across its terminals before and after each of the standard impulse tests, as well as before and after the additional tests that are specified by Eskom. The resistance should not change by more than 5 %.

It is further recommended that carbon composition resistors, rather than film resistors, be utilised for GLDs. The surge performance and ageing of carbon composition resistors are believed to be superior.

Operation verification test

Besides the resistor, the other sub-components of the GLD can also be damaged during the impulse tests. In order to ensure that the GLD is still in a working condition after being subjected to each impulse test, it is specified that the actual operating time of the GLD be measured. The requirement for an operating time of less than 3 s for a 5 A current is arguably the most arduous in the power frequency domain.

The new specification requires confirmation that the operating time of the GLD at 5 A is still less than 3 s, after completion of each of the impulse tests.

Conclusion

International specifications for surge arresters focus mainly on the arrester, neglecting the GLD. The specified requirements do not adequately cover the performance, duty and reliability of the GLDs.

Eskom developed the following six additional test requirements to confirm that GLDs are suitable for application on the Eskom network:

- Time versus current curve test
- High lightning duty current impulse withstand test
- Repetitive surge withstand ability test
- Thermal pre-conditioning and water immersion test
- GLD resistance measurements
- Operation verification test

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Definitions

Effective impulse duration: For the purpose of this paper the effective impulse duration is estimated as the difference between the virtual time to half value on the tail of an impulse and the virtual front time of an impulse, i.e. $T_2 - T_1$.

Tail of an impulse: The part of an impulse which occurs after the peak. [1]

Virtual origin of an impulse: The point on a graph of voltage versus time or current versus time determined by the intersection between the time axis at zero voltage or zero current and the straight line drawn through two reference points on the front of the impulse. For current impulses the reference points shall be 10 % and 90 % of the peak value.

Virtual front time of an impulse (T_1): The time in microseconds equal to 1,25 multiplied by time in microseconds for the current to increase from 10% to 90% of its peak value. [1]

Virtual time to half value on the tail of an impulse (T_2): The time interval between the virtual origin and the instant when the voltage or current has decreased to half its peak value. This time is expressed in microseconds. [1]

Wave shape (T_1/T_2): The shape of a voltage or current impulse is defined by the virtual front time (T_1) and the virtual time to half value on the tail (T_2) and is indicated as T_1/T_2.

Abbreviations

GLD: ground lead disconnector
IEC: international electrotechnical commission
IEEE: institute of electrical and electronics engineers
MOV: metal oxide varistor
MV: meduim voltage
SEF: sensitive earth fault.

Network master planning methodology for network expansion and renewal

by Marius du Preez, NETGroup International, and Ed Bunge, Eskom Eastern Distribution Region

This paper addresses Eskom's latest approach to long term investment in their distribution business. An overview of international trends with respect to long term electricity network expansion planning is provided.

The paper also summarises Eskom's latest planning methodology that incorporates some new trends key to the successful implementation of the universal access plan recently launched by government. A new methodology document has been formally accepted as a guideline to be applied both within Eskom and by private firms contracted to do work for Eskom.

"The objective of distribution planning is to provide an orderly and economic expansion of equipment and facilities to meet the utility's future electricity demand with an acceptable level of reliability" [1].

During April 2006 Eskom Management took the decision to undertake the universal access plan (UAP), which will provide a comprehensive expansion plan aimed at accelerating the pace of Electrification to ensure 100% access to electricity in South Africa by 2012.

Other drivers for comprehensive electricity network planning include:

- the national accelerated and shared growth initiative for South Africa (ASGISA), a government initiative aimed at achieving and sustaining a higher economic growth rate to ultimately halve poverty and unemployment by 2014.
- the need to make additional capacity available due to rapid load growth.
- the need for extensive refurbishment due to the age and performance of equipment and networks in certain areas.
- the increasing lead times required for environmental assessments, servitude acquisition and procurement of equipment.
- the findings of the CTAD audit on the network planning environment

In support of these initiatives, it will be necessary to ensure that adequate network capacity is available to supply the anticipated load demand. This will be done by conducting timeous network master planning (NMP) and network development planning (NDP) studies. This document summarises the standard approach to be adopted by all parties required to execute studies and compile NMPs and NDPs by and on behalf of Eskom Distribution.

Delivery of electric power is a capital-intensive business. The quantity of power needed, its location and when it will be needed; all have to be planned well in advance. The network planner's task is to determine an orderly and economical expansion of assets that meets Eskom's future electricity demand with an acceptable level of operability and reliability.

Planning philosophy

Background of the electricity supply industry (ESI)

The ESI has been through an evolutionary process since its inception approximately 100 years ago. Initially and for many years the business was seen as a high technology business, essential for economic growth and with a monopolistic characteristic. The default approach all over the world was to declare the business a natural monopoly to be owned and regulated by government.

Since the early 1970s this started to change.

These changes resulted in some changes in the ESI that can be categorised as follows:

- Regulated stable environment (pre-1970s)
- Regulated unstable environment (1970 – 1990)
- Regulated competitive environment (1990s onwards)

Traditional way of planning

The traditional way of planning in the regulated stable environment was characterised by the following:

- The responsibilities and mandate of the utility was clear and was strictly controlled by government.
- The demand was predictable and a long-term estimate of demand growth was quite possible. Long term load forecasting was done with a reasonable degree of certainty.
- Resources to meet the forecasted demand could be identified far into the future and rather accurate assumptions could be made about capital expenditure on network infrastructure.
- Different network development alternatives could be compared with certainty and far into the future. Aspects such as equipment performance, system reliability and financial requirements could be quantified with an acceptable amount of certainty.
- Resource plans could be implemented where the risk was manageable.

The conventional approach to planning could easily optimise the cost of supply to the utility.

Integrated resource planning (IRP)

The planning technique adopted in the regulated unstable environment between

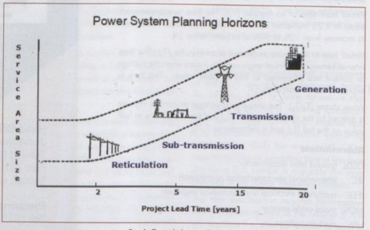

Fig. 1: Typical planning horizons.

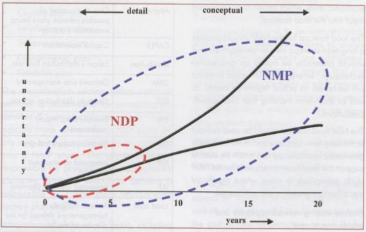

Fig. 2: Time perspective of NMPs vs. NDPs.

the 1970s and 1990s is called integrated resource planning and was characterised by the following:

- Utilities were still strongly regulated and the government still influenced management strongly.
- Load forecasting became more difficult and forecasting scenarios and stochastic techniques became more popular. Load forecasting had to recognise DSM initiatives and the effects of these on the demand trend line.
- Identifying generation resources included new alternatives such as purchasing power and DSM instead of building expensive new power plants.
- Analysing and evaluating all the system expansion alternatives were much more difficult as the required data increased exponentially and the number of options increased significantly.

Least cost planning (LCP)

LCP also originated in the regulated unstable environment and is followed in the initial stages of market liberalisation. Basically the LCP process is similar to the IRP process as described above but with the following distinct optimisation criteria that seem to dominate:

- Minimise tariffs
- Minimise capital requirements
- Minimise kWh (energy) consumption
- Minimise losses

Value based planning

One major component missing in the planning processes discussed above is that the cost of unreliability of the power system or the unavailability of electricity supply to the customer is not factored into the total cost. Lately the concept of minimising total cost – to both the utility and to the customer is becoming the norm to select the most optimal network expansion alternative.

In order to calculate indices such as expected unserved energy (EUE) and loss of load probability (LOLP), it is necessary to employ probability techniques. Such indices can be used to compare network expansion alternatives.

Calculating probability indices for the power system calls for statistically based techniques such as Monte Carlo simulation and contingency enumeration techniques. By using outage frequency and outage duration data for each component of the network, the probability of interruptions at each load point can be calculated.

Generally speaking value based techniques as described above are more suitable to assist with planning decisions in an environment where a greater amount of uncertainty exists as is common in liberalised wholesale markets. Electricity market reform is sweeping through the world and will most certainly influence the way utilities plan the development of their network – such influences will also have an influence on the South African electricity supply industry.

Planning methodologies

A variety of planning approaches are in use worldwide. The success of specific methods depends on the type of system and planning environment.

In recent times, the success of planning methods has been largely influenced by the industry structure.

Generally speaking, planning is a decision-making process that can be broken down into five generic steps as shown in Table 1:

Step	Activity	Notes
1	Identify the problem (includes gathering and analysing data)	Explicitly identify the range of application and its limits. Try to see the problem in terms of the goals and write it down.
2	Determine the goals	This tells you where you are aiming to go. What goals are to be achieved? Review the company's mission. What is to be minimised?
3	Identify the alternatives	What alternative solutions are available? This is a critical step. Never assume that one man can see all the alternatives. This should be a group session.
4	Evaluate the alternatives	Evaluate all the alternatives on a sound basis.
5	Select the best alternatives	Select the alternative that best satisfies the goals with respect to the problem

Table 1: Planning process.

Eskom's planning process

Overview

Fig. 3 illustrates a general process to conduct network planning and includes new features identified as necessary to stay in step with industry requirements. This process applies to both NMP as well as NDP. It is a holistic approach and addresses all aspects of Eskom Distribution's network infrastructure planning, including the bulk supplies to support the national electrification drive.

Planning study objective and review of study area

This first step is of a universal nature and sets the stage for the particular study, be it a NMP or a NDP.

The network planner should allow for a clear definition of the primary and secondary objectives of the study, the confirmation of the study area, the recorded network needs and eventually the development of a problem statement.

Even though network study areas may previously have been defined, these should always be reviewed to adjust for network or organisational changes.

Gather and verify network and load information

During this task appropriate information to support the study should be obtained. Planners require a wide variety of raw data and processed information to compile an effective plan. This includes mostly network and load related data but should also investigate the availability of information related to the environment, as well as plans for other services such as transport and water.

Specific assessments are conducted by the responsible parties to provide comprehensive information to the planners for integration into either the NMP or NDP.

This task further entails a quality review and indexing of all obtained information. Field visits may be required to verify network layout and equipment data. Where load recordings are not available it may be necessary to launch an exercise to install special recorders to obtain the required loads.

Load forecast and strategic study

The load forecast is a crucial input to both NMPs and NDPs. During this task a load forecast is developed that is based on regional demographic and historical load growth patterns, together with inputs such as regional electrification plans, local economic development (LED) plans, spatial development frameworks (SDFs) and other infrastructure development plans, often contained in municipal integrated development plans (IDPs).

It is important that the network planners have good insight into socio-economic developments by both public and private sector. Regional planners and economists should be utilised to conduct a strategic socio-economic study, which serves as an important input into the load forecast.

The load forecast for the NMP should provide a long-term strategic view on development and should preferably be based on geo-spatial techniques, where the NDP load forecast will be based on actual registered needs, as well as short-term trending type load growth predictions.

The NDP load forecast should be used as input to the long-term load forecast. A full long-term geo-based load forecast can in turn be used to support the load forecast required for the NDP study, particularly in areas where significant electrification growth is still anticipated.

Analyse existing network capability and problem statement

This task should analyse all the data and information gathered during the previous steps or by others outside the planning process such as network operators.

A typical activity would be to develop adequate network models representing the sub-transmission and/or reticulation networks within the study area. Once these models have been confirmed to be an acceptable representation of the real world, future loads as projected by the load forecasting exercise can be applied to the network models and analysis studies can confirm shortcomings of the existing network.

The planner should then analyse and address the shortcomings in a coordinated manner and finally clearly define the network problems that have been identified.

Integration of plans

The planner, in consultation with the relevant stakeholders, needs to integrate the various discipline specific plans into the overall network plan, either at a strategic level for a NMP or at a more detailed project level for a NDP.

Alternative	One of a number of possible network plans being evaluated in a study
CAPEX	Capital expenditure
Distribution	Eskom's distribution business
DSM	Demand side management
EDI	Electricity distribution industry
EIA	Environmental impact assessment
ESI	Electricity oupply industry
IDP	Integrated development plan(ing)
IRP	Integrated resource planning
Load zone	An area (typically homogeneous) defined for the purpose of analysis
LCP	Least cost planning
NDP	Network development plan(ning)
NMP	Network master plan(ning)
OPEX	Operating expenditure
Reticulation system	Typically MV reticulation ≥1 kV and ≤33 kV, LV reticulation <1 kV
Scenario	A postulated future event or sequence of possible events
Sub-transmission system	Typically 44 kV and ≤132 kV sub-transmission network
Transmission system	Typically 220 kV – 765 kV transmission network (unless otherwise stated)

Table 2: Abbreviations and definitions.

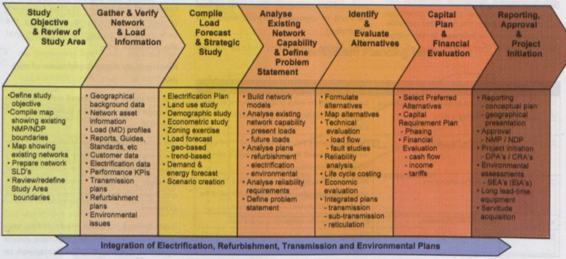

Fig. 3: Eskom's planning process.

These include the following plans:

- Electrification plan
- Refurbishment plans
- Transmission plans
- Environmental plan
- Reliability plan

The electrification section within customer services is responsible for compiling the detailed 5 year electrification plan. This is typically more relevant for a NDP study, but any long-term plans should be incorporated into a NMP study. The plant section is responsible for primary plant refurbishment planning, and the electricity delivery is responsible for control plant refurbishment section planning.

Integration of plans at all levels, including transmission, sub-transmission and reticulation requires effective communication between stakeholders. Special emphasis is required for liaison with the Transmission Expansion Planning section, which is organisationally separated from distribution network planning.

It is important to develop a common vision between all parties involved in network investment for the long-term development and renewal of the network over time.

Identify and evaluate alternatives

The objective of this task is to identify possible network solutions and to perform technical evaluations on these alternatives to ensure that the identified needs are addressed. Care should be taken to ensure that the level of technical capability of each network development alternative is more or less equal so that economic evaluation can be done fairly on each alternative.

Network analysis will adhere to the planning criteria as described in the distribution code and the network planning guideline.

The economic evaluation should collectively assess all costing factors influencing the viability of the plan and should consider both the cost of new infrastructure as well as the life cycle cost of operating and maintaining the infrastructure.

Capital plan and financial evaluation

The objective of this task is to refine and phase the capital cost of the preferred network development option.

As a minimum, the cost estimates should be based on the requirements for the following project business categories:

- Direct customer
- Electrification
- Strengthening
- Refurbishment
- Reliability

It is sensible to do a financial analysis of the recommended network plan in order to confirm that the capital program will still meet cash flow and net income requirements of the strategic and business plans.

Reporting, approval and project initiation

This task is of a general nature and touches on all the steps mentioned above. The task outlines the requirements for:

- Reporting, i.e. summary reports - the approach, findings and recommendations of the planning studies
- Approval of NMPs and NDPs in line with the capital investment process and network asset creation value chain.
- Project initiation, i.e. the release of projects into the business.

It includes the identification of long lead-time equipment, environmental assessments and servitude acquisition.

Conclusion

This document describes the main steps to

be followed by network expansion planners involved in the long term development planning of Eskom's distribution networks.

The document will be continuously reviewed and updated in order to stay in step with international best practice and also to address South Africa's needs for electrical energy. Aspects that will receive more attention in the near future are network reliability and economic evaluation. It is foreseen that these aspects will be incorporated into future updates of the methodology guideline.

The process may seem extensive but when compared to the amount of capital that will be spent on distribution network expansion and renewal it makes sense to follow a process as described as this will lower the risk of fruitless or non-optimal investment related expenditure.

Definitions

Refer also to Table 2.

"Distribution networks": All sub-transmission and reticulation electrical equipment (substations, lines and cables) owned and managed by Eskom's Distribution Group, from 132 kV to LV (400/230 V).

Rural network: Network serving clustered or scattered structures, usually of low density, not served by well established infrastructure (i.e. roads, water, sewage, electricity).

Urban network: Networks serving formally or informally built structures, usually of high density, serviced by well established infrastructure (i.e. roads, water, sewage, electricity).

"Network planning process": This is a process for assessing the ability of all network infrastructure to meet industry standards in respect of existing load, future load forecasts and reliability requirements.

"Network master plan (NMP)": A NMP consists of all the documentation that is produced during the network planning process where the focus is long-term and strategic. This documentation (i.e. software files and paper records) is required to support the strategic capital plan and needed to review and revise the plan in the future.

"Network development plan (NDP)": A NDP consists of all the documentation that is produced during the network planning process where the focus is short to medium term in relation to the NMP. This documentation (i.e. software files and paper records) is required to support the 5-year capital business plan and is needed to review and revise the plan in the future.

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Universal access to electricity - Eskom's business plan

by Peter Sebola, Eskom Distribution, Anton Theron and Ferdi Nel, NETGroup

This paper addresses the business plan prepared by Eskom for the program required to support the government's vision of universal access to electricity by 2012. It describes the methodology followed to compile the universal access plan (UAP) through a desk top analysis based on the best available geospatial information as well as the knowledge and experience of both demand side and supply side planners.

It also provides main results emanating from the plan and insight to backlog, network expansion, load, costs and resource requirements for such an initiative on a national basis. The UAP shows that although great strides have already been made, much work still lies ahead to provide universal access to electricity for all.

Universal access was recognised when President Thabo Mbeki stated, "Through our integrated system of government, with the strengthened local government working with our state enterprise, Eskom, we will, within the next eight years, ensure that each household has access to electricity" during the State of the Nation address on the 21 May 2004.

Universal access is not a new concept in government departments. It was always a topical issue on government's agenda. However, only in 2004 was a committed timetable officially extended to the nation.

Government had stated a clear desire to provide affordable access to energy services including electricity since the 1990s. National leadership recognised that household access to energy services is a basic need. A lack of access to electricity means that basic needs will not be met.

The production and distribution of energy must be sustainable and any plans developed, must be long term solutions. The deputy minister of minerals and energy stated that an integrated programme that utilises both grid and non-grid technologies will allow for electrification to be sustained.

In broader statements government also highlighted the need for electrification for minority groupings as a matter of urgency. These minority groups include: disadvantaged households, small businesses, small farms and community services. It is necessary for the electricity supply industry to contribute towards social equity by addressing the electrification needs of the poor.

Electrification has not only been mentioned in national addresses and white papers, but also serves as a central component of the reconstruction and development plan's (RDP's) infrastructure delivery programme.

UAP project context

The Department of Minerals and Energy (DME) contracted Eskom through ESI-GIS to provide a universal access planning approach for electrification.

In February 2006 ESI-GIS presented statistics to Eskom, DME and AMEU which indicated a current backlog of electrification connections of approximately 3 million households, with an estimated requirement of 5 million connections by 2012.

The workshop agreed that a plan to manage "universal access" is required and Eskom offered to prepare a proposed project charter on how the plan might be prepared.

Eskom through ESI-GIS has contracted with DME to undertake this work, and has structured the work into three phases with support from various project teams. (see Fig.1) The three phases are:

- *Phase 1 (short term):* To formulate a high level planning proposal to achieve universal access in line with government objectives
- *Phase 2 (medium term):* Formulate a planning proposal per municipality for the current medium term expenditure framework (MTEF) 3 year cycle and refine the planning proposal as provided in Phase 1
- *Phase 3 (long term):* To establish and recommend a long term approach for the development of the universal access plan (UAP)

ESI-GIS completed a combined Phase 1 and 2 report in 2005. This report has provided indicative estimates of Government funding required to meet electrification backlogs, based on various scenarios and assumptions for the quantity and cost of connections.

The objective of Phase 3 was a detailed approach to the development of a Universal Access Plan. Due to the magnitude of the programme, Phase 3 was split into two stages namely:

- *Stage 1:* Electrification
- *Stage 2:* Integrated network plan

Typical deliverables from Phase 3 include the electrification plans, network development plans and master plans required to achieve universal access while considering operation and commercial functions to ensure the business can support the programme.

The following workstreams were identified to ensure a comprehensive plan:

- Electrification planning
- Master planning
- Strategic studies
- Data management
- Geo based load forecasting
- Refurbishment
- Operations
- Commercial
- Programme and journey management

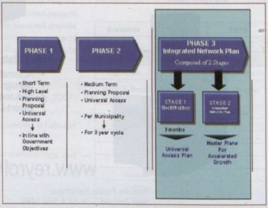


Fig. 1: Programme phase and stages.

Phase 3 Stage 1: Electrification

Objectives

Stage 1 allowed Eskom to gain a better understanding of the extent of the programme and provided for better Stage 2 estimates. The objectives of Stage 1 were to develop a universal access plan, to identify enhancements that would improve planning in future iterations as well as develop a business case. In order to achieve these objectives the following streams were mobilised:

- Data management
- Strategic studies
- Electrification and network planning
- The integrated planning system (TIPS) enhancements
- Master planning methodology
- Programme and journey management

Scope

The following scope was agreed with regards to the development of the universal access plan:

- Only Eskom areas of supply are considered for the development of the connection schedule
- Eskom as well as municipal electrification loads are considered with regards to the national sub-transmission infrastructure plan. This was considered for funding purposes but municipal electrification was not incorporated in the geospatial expansion plan
- The current electricity industry structure is assumed to remain during the timeframe of the project. Plans will have to be assessed and updated in the event of industry restructuring
- Strategic studies to provide a high level view regarding the household growth as input to

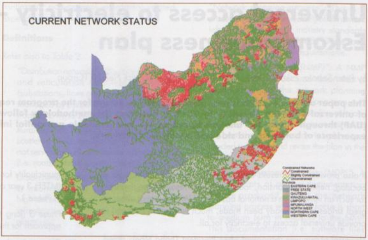
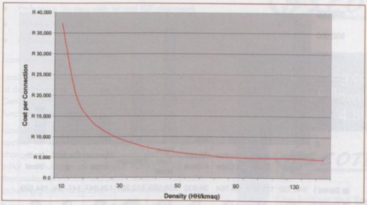


Fig. 2: Network constraints.



Graph1: Cost per connection based on density.

Category	Density	Saturation ADMD (kVA)
Urban	Proclaimed	1,90
Peri-urban	>150	1,25
Rural1	110 to 150	0,85
Rural2	70 to 110	0,80
Rural3	0 to 70	0,65

Table 1: Backlog estimates.

the universal access plan and the business case that can be refined in Stage 2.

Deliverables

A six-year universal access plan

- Concept release approval (CRA) forms for projects identified in the first three years
- Geospatial representation of the projects
- Costing and resourcing for the projects;• Sub-transmission plan
- Generation and transmission inputs

Evaluation of commercially off the shelf applications to replace TIPS

- Design specifications to enhance TIPS for future planning iterations
- Enhancement of the current Eskom master planning methodology
- Business case

Approach

Settlement data was required in order for the electrification and network planning stream to develop geospatial plans. The data management stream investigated the available Eskom data and obtained settlement data from institutions including the Department of Water Affairs and Forestry (DWAF).

The regions were also requested to provide their three year rolling plans as input. This data was analysed in workshops with the respective regions in order to resolve gaps. The data was then handed to the electrification and network planning team for further analysis. The electrification and network planning team conducted several workshops per region in which they:

- Filled in data gaps and pologonised the projects geospatially
- Prepared integrated development plans (IDP's) aligned 6 year connection plans
- Identified network constraints
- Iteratively planned network expansion and electrification projects over the 6 year period

At the same time, the strategic studies team prepared a best estimate for the growth and provided the information in the required format to the electrification and network planning stream, as input to the plans.

Phase 3 Stage 2: integrated network planning

The primary objective of integrated network planning is to develop master plans for a 20 year horizon for all regions across the country. Master plans will be developed according to the master planning methodology developed in Stage 1. Master plans will enable network development planning and associated projects over a 5 year horizon. These plans will provide planning input for infrastructure projects required to support electrification projects in both Eskom and municipal areas.

Status of phase 3

- *Stage 1:* Completed in January 2007. Accepted and approved
- *Stage 2:* Approved and initiated in February 2007

This paper focuses on the methodology and results for Phase 3 – Stage 1.

Methodology

Definition of universal access

The definition that has been submitted to DME

Green	No constraint on networks, electrification can proceed and all backlog in this supply area can be supplied.
Orange	Slightly constrained networks, electrification can proceed with caution but not all backlog in the supply area can be cleared, strengthening has taken place.
Red	Constrained networks, no electrification can proceed without network strengthening first taking place.

Table 2: Network breaker constraint categorisation.

during Phases 1 and 2 of the programme was as follows:

To provide all previously disadvantaged South African households with access to basic electricity by 2012, under the following conditions:

- Grid electrification will be utilised, as an option of choice while other technologies will be considered as a means of an interim solution
- Within the constraints of access to resources and time, these alternative solutions will be replaced through a process of continuous improvement in line with the expected asset lifecycle of the alternatives, even if the process continues beyond 2012
- In remote areas where grid electrification is inaccessible, technologies can include: solar; gas; liquid fuels, mini-grid; renewables; and a combination of the above.
- Households to be electrified will be restricted to authorised settlements (proclaimed and tribal land), but exclude the following: unproclaimed areas; and settlements on unsafe ground formations and areas in the flood lines.
- A basic supply refers to the following:
  - Grid: <10 A, 0,6 kVA ADMD
  - Non-grid: 50 W peak solar system,

Backlog

The Census 2001 information is generally accepted as the formal and most accurate

Scenario	2006	2012
Low Case	1 887 886	2 188 565
Base Case	1 989 221	2 540 713
High Case	2 111 639	3 628 854

Table 3: Backlog estimates, Eskom supply area.

Region	Connections
Central	30 000
Eastern	120 000
Northern	75 000
North Western	12 000
Southern	10 000
Western	10 000
Total	257 000

Table 4: Connections possible within network capacity.

source with regards to determining the electricity backlog. The census question from which the electricity backlog is derived seeks to determine the energy source mainly used by the household for lighting purposes.

Census information therefore does not measure electricity grid connections explicitly but that it measures a household's access to electricity for lighting purposes.

Eskom is ultimately interested in the actual number of connections that need to be made in order to provide universal access to electricity. However, there is a conceptual difference between a physical electricity connection or supply and the demographic concept of a household

Backlog is defined as all existing housing units which do not have access to electricity and includes:

- "Brown fields" or infills – Potential connections that are within a range of 300 - 550 m of existing pre-paid distribution transformers
- "Green fields" – potential connections that are outside these respective boundaries
- Known formal housing projects as provided by regional planners

The generic approach to determine backlog was:

- Exclude non-Eskom supply areas (all municipalities licensed to distribute)
- Establish a buffer of up to 550 m around all electrification transformers
- Count all households from 2001 HELP database inside and outside this buffer;
- Brown fields (infills) determined from the count inside the buffer less existing prepaid customers
- Green fields determined as the count outside the buffer less existing land rate customers
- Results adjusted by Strategic Studies Team delta data to provide for growth during the period 2001 to 2006

Planning process

A classical planning approach could not be applied to this assignment due to the short time frame. A high level qualitative approach was taken which relied on the knowledge and experience of Eskom electrification and network planners of what, how and when projects need to be completed to achieve universal access to electricity.

Three workshops were conducted per region of which the objectives were the following:

- *Workshop 1: Demand side planning;*
- *Workshop 2: Supply side planning;*
- *Workshop 3: Finalisation*

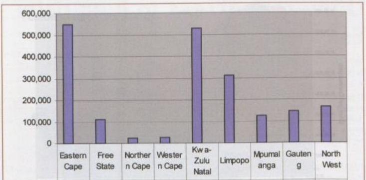
Planning decisions taken in the workshops with the regional and network planning managers were recorded spatially in an ArcView geospatial information system (GIS) platform. The GIS is not a model with built in functionality to evaluate scenarios but enables the geospatial representation of the plan and facilitate costing.

The DME regional energisation managers were invited to these sessions to ensure as close as possible IDP alignment given network capacity constraints.

Eskom electrification planners were requested to define project polygons for the backlog identified in the workshops. These polygons represent projects that have been identified in the current Eskom three year rolling plan as well as the remaining known backlog.

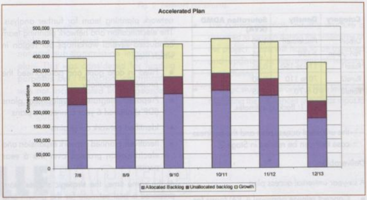
Projects in the current three year rolling plan were reviewed against network capacity. Projects which were not possible due to network capacity constraints were moved out of the three year plan and replaced with suitable alternatives.

The remainder of projects were then allocated a new project year, to achieve the electrification in the 6 year period according to:

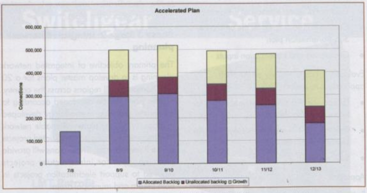


	Eastern Cape	Free State	Northern Cape	Western Cape	Kwa-Zulu Natal	Limpopo	Mpumalanga	Gauteng	North West
Series1	548,192	110,679	24,764	28,632	528,060	312,364	124,847	147,094	164,589
Series2	28%	6%	1%	1%	27%	16%	6%	7%	8%

Graph 2: Backlog per province.



Graph 3: Accelerated connection schedule, no constraints.



Graph 4: Accelerated connection schedule, with F07/08 approved budget.

- Preference (six-year wish list and IDP alignment)
- Network capacity
- Logical network expansion

Load and energy estimate

Load forecasts were determined through a process of determining an estimated After Diversity Maximum Demand (ADMD) loading per 20 A connection as a function of the settlement density (see Table 1).

Load growth curves, based on past research, were then applied for each settlement category to establish the change in ADMD values over a twenty year period from initial to saturation values. These ADMD values were then multiplied with the number of connections per year, including growth, to establish a load forecast.

Energy consumption was related to the ADMD values using the NRS 034 Load Research data. The results from the load forecast exercise were then used to profile the additional generation energy required.

Network constraints

The existing network constraints per network breaker were evaluated following discussions with the area network planners and categorised (see Table 2).

Existing Eskom projects affecting these constrained networks were captured to determine the status of the networks from FY 07/08 onwards. This exercise highlighted networks that had a status of orange or red but which did not have strengthening/capacity projects in place as yet.

Additional sub-transmission expansion projects were then identified with the Area Network Planers to address these constraints taking into account project lead times. The final list of expansion projects contains both current NDP (Eskom initiated projects) as well as projects that are necessitated by the Universal Access requirements. The result is a change in status of networks from orange or red to green over the implementation period (2006 – 2012).

Reliability

Reliability criteria, as per regional preferences, were applied into the expansion planning process.

Costing and material estimation

An electrification cost curve and associated material ratios were developed from a sample of recently completed projects with different settlement densities for the planning model (see Graph 1).

Sub transmission cost modules and ratios were also derived from recently completed projects for the planning model.

Resource requirements

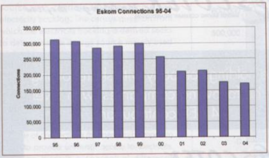
Resource estimates both at electrification and sub-transmission level were made for:

- Consultants
- Surveyors
- Contractors (small, medium and large).

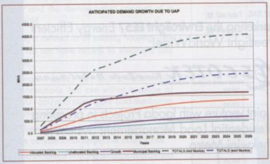
Results

Backlog

High and low scenarios were developed as part of



Graph 5: Eskom connection history.



Graph 6: UAP increase in demand.

the modelling exercise to illustrate the sensitivity with regards to the assumptions. In order to construct the high case scenario, it was assumed that government capital spending is adjusted 10% upwards and that the AIDS prevalence rates saturate and decline to 18% in 2012. For the low case scenario, it was assumed that the government spending is 10% lower than the base case and that the AIDS prevalence rates remain constant at 23%. The results of these two scenarios for the Eskom areas of supply can be seen in Table 3 and Graph 2.

Accelerated plan to meet 2012 targets

- *Scenario 1 - no constraints:* Graph 3 depicts the accelerated plan without taking constraints into account for the Eskom area of supply.

  The maximum number of geospatially allocated backlog connections that can be done before running into network constraints can be seen in Table 4.

  Substantial infrastructure will therefore be required by FY08/09 to enable universal access.

- *Scenario 2 – pragmatic plan:* Funding allocated towards the Eskom electrification programme by Government for FY 07/08 is in the order of R 1bn (excluding VAT).

  Assuming the budget and connection figures for FY 07/08 above, some projects would need to move to later years (see Graph 4).

  The number of connections completed by Eskom in the late 1990's to the middle of the 2000's is illustrated in Graph 5.

As illustrated, Eskom was able to complete approximately 300 000 connections per annum in the middle to late 1990s. These numbers are of the same order of magnitude as the geospatially allocated backlog scheduled in the plans above but substantially less if the growth and unallocated backlog is added. If the growth and unallocated backlog are added, the required connections will be in excess of 500 000 per annum.

Industry resource constraints is of concern for the universal access programme. It is believed that due to scaling down of electrification programmes in the recent years, many consultants and contractors associated with electrification have either changed their focus or moved to international markets elsewhere in Africa. Many Eskom resources have also been redeployed to other departments or have moved on since the electrification programme was at its height.

Furthermore equipment and material for electrification projects are sourced internationally in many instances and prices as well as supply are influenced by several factors.

Table 5 summarises high level estimates of materials and resources required to achieve universal access by 2012.

Critical success factors

- The plan is currently based on Eskom areas of supply only. In order to have a national view of universal access and to refine the impact of municipal areas of supply on sub-transmission, it is crucial that municipalities that supply electricity are involved in future iterations.
- The data on which the electrification plan was based needs to be verified. Issues with the settlement data have been identified. Future projections are based on Census 2001 data, which is old and only available on municipal level. The accuracy of the plan should be enhanced through the use of satellite imagery and/or aerial photography. If this is done, an update to the plan will be required.
- The geospatial plan should be maintained on a regular basis to ensure that the information captured is not lost, going forward. This would require regular updates to the plan with input from the regional electrification planning coordinators, land development and project engineering.
- It is important that Stage 2 of the programme continues. This will not only allow an update to the electrification plan and improve the accuracy but would enable Eskom to produce master plans over a 20 year horizon.
- A supplier forum should be held in order to gauge the industry capacity and complete a pragmatic plan.
- It is important to understand how the national electrification programme will be affected by industry restructuring.
- As new customers are connected to the network, it is crucial that operational expansions are made to serve these customers e.g. creation of new technical service areas, creation of additional vending points etc.

UAP business plan summary

The cost reflected in Table 6 includes the cost of infrastructure projects required to support Eskom and municipal areas electrification. It includes the cost of Eskom areas of supply electrification projects but

	FY07/08	FY08/09	FY09/10	FY10/11	FY11/12	FY12/13
Meters	143 950	500 219	517 623	493 548	480 057	405 315
Poles	757 269	1 099 179	1 182 878	1 127 729	1 128 709	885 607
LV lines (km)	7 622	25 970	27 801	29 437	23 737	26 814
MV lines (km)	3 806	12 941	13 844	14 677	11 851	13 409
Trfrs (units)	1104	3579	4066	4477	3376	4247
Trfrs (MVA)	66	211	233	200	230	181
HV lines (km)	799	10797	2335	3343	1167	630
HV substations	31	60	45	10	8	0
Consultant	25	84	86	83	82	64
Surveyor	12	42	44	39	39	32
Contractor large	17	62	69	62	58	51
Contractor small	83	293	292	287	281	237
EIAs	40	70	60	9	7	2

Table 5: Estimated material and resources.

Backlog	2 540 713
Load	4000 MVA
Cost	R 24,7-bn

Table 6:

not that for municipalities that have distribution licenses. The backlog of 2,54-million is for Eskom supply areas only, while it is estimated that the total electrification backlog (including municipalities) is approximately 3,4-million connections (in 2012 terms).

Conclusion and recommendations

The current proposed plan takes the funding allocation for FY07/08 into account. The result is a plan to eradicate backlog by FY12/13 that requires up to 500 000 connections per year. Considering what has been historically possible, 500 000 per annum appears high considering that in the late 1990 s, when the electrification programme was at its height, Eskom connected at a rate of 300 000 connections per annum.

In the accelerated plan, taking into account the funding allocation for FY07/08, approximately 300 000 geospatially allocated connections are planned per year which is similar to the maximum that Eskom has been able to achieve in the 1990s.

It has also been found that a skills shortage exists in the Eskom structures should the plan be accelerated, especially with regards to buyers, environmental advisors, project coordinators, project engineers and electrification planners.

The funding allocation for FY07/08 allows Eskom the opportunity to further improve on the accuracy of the backlog and if satellite imagery for the following three years is procured, trends could be established to verify connection growth assumptions. Also, as mentioned above, the backlog has been determined through desk top studies and it is imperative that the figures are verified either through site visits or by satellite imagery.

Satellite imagery would also allow for the incorporation of the municipal areas of supply for sub-transmission planning purposes which have not been done on a geospatial basis. The fact that the programme is not accelerated in FY07/08 also affords Eskom the opportunity to "up-skill" resources in the electrification area and to prepare for future years when the plan is accelerated.It is also important that the supplier forum is organised and that the results from the forum are used to update the pragmatic plan in the business case and to verify the assumption of 300 000 connections per annum.

Definitions and abbreviations

Distribution networks: All sub-transmission and reticulation electrical equipment (substations, lines and cables) owned and managed by Eskom's Distribution Group, from 132 kV to LV (400/230 V) with subsets as follows:

Reticulation Networks: 230 V – 22 kV

Sub transmission Networks: 33 kV – 132 kV

Scenario: A postulated future event or sequence of possible events.

Refer to Table 7 for abbreviations used. Δ

UAP	Eskom's distribution business
DME	Department of Minerals and Energy
ESI-GIS	Eskom Data and GIS Agency
AMEU	Association of Municipal Electricity Undertakings
TIPS	The integrated planning system
NDP	Network development plan

Table 7: Abbreviations.

Meeting increased load growth and improved network reliability

by Dr. CG Carter-Brown and R Stephen, Eskom

The country faces significant challenges to maintain and improve network reliability in the face of a significant increase in load growth and demand.

The challenges faced by Eskom Distribution Network Planning include the following:

Load growth: load growth has doubled as compared to the early 1990s. The number of network planners in Eskom has not increased proportional to the increase in load growth. Planners need to produce more, and need to be more effective.

Universal access planning (UAP): the target to complete universal access to electricity by 2012 places an additional burden on planners to ensure that network infrastructure can support this additional load.

Reliability: incentive based regulation (IBR) and network performance targets necessitate that Eskom Distribution improves present network performance levels. A major step change in performance can only be achieved in conjunction with capital expenditure related to network redundancy and risk (reducing the number of customers and size of load at risk for network faults). Planners need to include reliability implications in network investment decisions.

Capital expenditure (primary plant planning and design) is a key aspect of network reliability improvement, but it is recognised that there are other business aspects such as systems and data collection methods, performance measurement and reporting standards, operation and maintenance practices, system automation, telecontrol, SCADA visibility and staff skills and training.

Data: planners, it is estimated, presently spend 80% of their time searching for data, and 20% of their time performing actual planning (load forecasting, need identification, alternative evaluation etc.). Essential data needs to be validated and available for easy export to planning tools.

Staff turnover and skills: The average experience of a network planner is typically less than 2 years. Staff turn over is high. Training systems are required to get new planners up to speed in the shortest time possible. The knowledge/plans of existing planners need to be available for easy reference by new planners. A career path needs to be created to retain experienced planners.

Distributed generation (DG): The requirement to integrate co-generation and renewable generation requires a new set of skills as distribution planners traditionally do not have experience with the integration of generation.

Demand side management (DSM) and local integrated resource planning (LIRP): DSM and LIRP require planners to assess both supply side and demand side alternatives to network constraints. Optimal solutions could involve DSM and/or utility owned distributed generation. Additional data, skills, models and tools are required for these assessments.

This paper describes current initiatives to address these challenges.

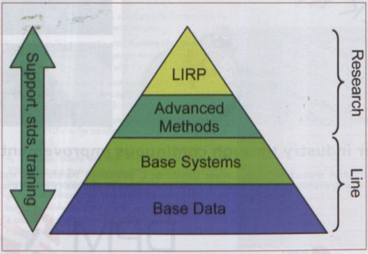


Fig. 1: Network planning dependencies.

Strategy

As per Fig. 1, effective network planning builds on base data and systems:

- *Base data:* essential data for power system analysis, load forecasting and alternative evaluation.
- *Base systems:* software systems for power system analysis (load-flow and fault-level), load forecasting and need and project registers.

Advanced methods (probabilistic risk assessment and reliability analysis) and LIRP can only be implemented once base data and systems are in place.

Cutting across all of the above mentioned components is the need for support, standards, guidelines and training.

The strategy adopted by Eskom Distribution is as follows:

- Base data and systems are critical, and will typically be addressed via line projects and initiatives (short term within 18-24 months).
- Advanced systems and LIRP can' only be effective once base data and system issues have been resolved, and will typically be addressed via research (medium term between 1 and 3 years).
- Supporting standards, guidelines and training material will be developed and rolled out in conjunction with the delivery of the components.
- Overall coordination is performed via the Technology Steering Committee of Distribution (TESCOD) Network Planning Study Committee.

Base data

Present initiatives to address base data requirements include:

- *Data porting:* Eskom Distribution utilise the GE SmallWorld AM/FM GIS system as the primary data store for network information as required for network schematics, SCADA and power system analysis. HV and MV network location and connectivity is comprehensively captured in SmallWorld. However, certain attribute data required for power system analysis, such as conductor size, is incomplete and the accuracy of certain attributes is uncertain (in Smallworld) and captured accurately elsewhere. Much of this data is still contained in legacy systems and other databases such as Microstation as-built drawings, commissioning sheets and test sheets. A project has been initiated to port this data from these other systems and data sources into SmallWorld so that this data is readily available to the planner and can be exported to power system simulation software (see power system analysis).

- *Data processes:* The data porting project will also address the data processes, standards, commissioning sheets, test sheets etc. to ensure that the HV and MV network data required by planners is captured in SmallWorld for future network additions and modifications.
- *Standard values:* For the purposes of network planning studies, standard (typical) values for equipment attributes can be utilised. Examples include typical impedances and losses for transformers, and per-unit length impedances (R, X and B values) for power lines and cables. A project is nearing completion for the implementation of standard value libraries in SmallWorld such that typical attribute values are available for attributes that have not been populated via data capture.
- *Statistical metering:* There is renewed focus on remotely downloaded statistical metering such that load profile data of active and reactive power (30 minute interval) is available for all major power transformers (typically at HV/HV and HV/MV substations), HV lines/cables and MV feeders.

The net objective of these projects is to provide planners with easy access to critical network and load data.

Base systems

Power system analysis

Eskom Distribution utilise ReticMaster and DigSilent PowerFactory for power system analysis. ReticMaster is used for basic studies on radial MV and LV networks. PowerFactory is used for sub-transmission network analysis and advanced simulation such as protection coordination, dynamic and transient analysis and harmonic studies.

Eskom's present SmallWorld system only supports a write-out of MV networks to ReticMaster. A project is underway to provide integration between SmallWorld and PowerFactory. PowerFactory will then be utilised for power system analysis on both MV and HV networks utilising the network data stored in SmallWorld. This facilitates advanced reliability studies (section 5). ReticMaster will continue to be used for all LV studies, and basic radial MV studies.

A Master Type Library (MTL) has been completed and provides a single source of type library (standard) values for systems including SmallWorld, ReticMaster and PowerFactory. This ensures that the same standard values (impedances etc.) are utilised in all systems.

Project need register

The existing Project Need Register (PNR) in SmallWorld is being enhanced to provide planners with the following core functionality within the GIS:

- *Need register:* Needs are spatially located (GPS coordinates) so that interdependencies can be visualised.
- *Project register:* A project can have a number of alternatives, one of which is preferred. Each alternative can have jobs, network, costs, need dates, and other attributes associated with it. Alternatives can be written out to ReticMaster or PowerFactory for power system analysis. Projects and alternatives can be viewed spatially and are integrated with K2 project workflow and PowerOffice costing systems. Projects and alternatives can be linked to needs.

The PNR provides the planner with a GIS linked repository for needs, projects and alternatives such that this data is available throughout the enterprise and can be integrated with costing engines, workflow and power system simulation tools.

Geo-based load forecasting

Load forecasting is a critical component of network planning. Historically there has been no fully standardised system for load forecasting within Eskom Distribution Network Planning. Load forecasts were performed with differing methods in each region. Based on a comprehensive user requirement analysis, the following key requirements have been identified:

- *Load hierarchy:* Loads must be specified at multiple levels (connected to LV, MV or HV networks) and summated such that the loading can be viewed at these multiple levels i.e. HV levels include loads connected at HV, MV and LV levels.
- *Load profiles:* Profile models are utilised to model load diversity and forecast both energy and demand.
- *Small area and land based:* Forecasts can be performed for user defined areas of land, and results reported and visualised in the SmallWorld GIS.
- *Forecast methods:* A range of different forecast methods are required including growth curves, s-curves, land use, trending, electrification ADMDs and user defined forecasts.
- *Libraries:* Libraries are utilised to provide standard values (load factor, power factor, load profile) for typical customer classes.
- *Scenarios:* Multiple load forecast scenarios are supported.
- *PSA link:* Load forecast results are linked to ReticMaster and PowerFactory so that manual population of forecasts within the simulation packages is not required.

A project is underway to source a commercial "off the shelf" solution providing an acceptable fit to the user requirements. In the interim a locally developed and supported Microsoft Excel based load forecasting tool, PowerGLF, will be utilised. Rollout is expected to be completed in the fourth quarter of 2007. A load forecasting guideline has been developed to support the PowerGLF rollout.

Project evaluation model

Historically Eskom Distribution Network Planning selected preferred alternatives based on capital cost considerations and compliance with minimum standards. Consideration of increased network reliability and higher cost of technical losses necessitate a new approach.

A Project Evaluation Model (PEM) is being developed to supplement the Financial Evaluation Model currently in use, with the intention to consider lifetime economic costs associated with capital, technical losses, reliability and operating and maintenance. This model will be utilised to select and motivate the best technical alternatives.

Reliability

Reliability considerations are being addressed via the following initiatives:

- *Guideline:* A network planning reliability guideline has been compiled.
- *Training:* Reliability training forms one of the modules referred to in section 7.
- *Capex reliability link:* A project is establishing the capex solutions and costs to improve Eskom Distribution network performance. A key issue is an understanding of the scope and cost implication for the electrification UAP if a range of different performance targets are to be met.
- *Probabilistic reliability assessment:* Based on network models and equipment failure rates and repair times, the expected performance (SAIDI, SAIFI etc) of different network alternatives can be calculated. Based on Eskom Distribution requirements the probabilistic reliability assessment functionality in PowerFactory has been enhanced. This functionality will be rolled out in a phased approach for HV and MV

network analysis, and is dependent on the PowerFactory integration with SmallWorld (see power system analysis).

- *Asset utilisation reporting:* The level of asset (network) utilisation and risk will be reported via KPIs, for example the number of un-firm HV/MV substations.

Standards and guidelines

Eskom Distribution Network Planning standards and guidelines are published via the Distribution Technology IARC website. Certain standards and guidelines require revision. New standards and guidelines have been identified for compilation.

The following standards and guidelines have recently been revised/completed:

- *DGL 34-543:* Network planning guideline for MV shunt capacitors.
- *DGL 34-539:* Network planning guideline for MV step-voltage regulators.
- *DST 34-542:* Distribution voltage regulation and apportionment limits.
- *DISAGABL8:* Planning guideline for MV underground cable systems.
- *DGL 34-155:* Network asset cost of supply methodology.
- *DGL 34-431:* Eskom methodology for network master plans and network development plans (this guideline is the subject of a companion paper entitled "Modern Network Master Planning Methodology - an approach to address network expansion and renewal needs due to higher economic growth and socio economic needs").

The following standards and guidelines are in draft format pending formal approval:

- *DGL 34-450:* Network planning reliability guideline.
- *BGL 34-335:* Network planning philosophy.
- *DGL 34-619:* Network planning guideline for lines and cables.
- *DGL 34-617:* Network planning guideline for transformers.
- *DGL 34-1284:* Network planning guideline for geo-based load forecasting.

The standards and guidelines form the base material for the development of training material, as in the following section.

Training and development

In order to facilitate the understanding and implementation of the standards and guidelines, training material needs to be developed and formally presented. The following training modules have been identified:

- Planning process and methodology
- Network planning philosophy
- Reliability assessment
- Electrification planning
- Short and medium term load forecasting
- Long term load forecasting
- Project needs register
- Power system analysis
- Project evaluation
- Business planning
- Power system protection
- Transmission system planning
- Project life cycle
- Cost of supply
- Planning tools
- General skills

Three training modules are being targeted for completion in the 2007/8 financial year. Web based learning will form a core component of the training material, which will be formally accredited with ECSA.

As part of a broader skills retention program Eskom Distribution have commenced with an accelerated development program for specialists. The objective of the program is to accelerate the development of specialists within critical technical areas. Candidates within Network Planning have been short-listed for further evaluation. Successful candidates will be provided additional development opportunities and mentorship.

All of the standards and guidelines are available to the industry either free of charge or for a small administrative fee.

Management

Given the challenges faced with increased load growth, constrained networks, UAP and reliability improvement, Network Planning has received renewed focus from Eskom Distribution senior management. Examples include:

- *Industry Association Resource Centre (IARC) support:* A network planning sub-section has been formed to provide national technical support via three staff members.
- *National Network Integration Forum (NNIF):* All Eskom Distribution and Transmission projects ≥ R35million are presented to the NNIF for technical assessment. The purpose of the forum is to ensure alignment and integration between Distribution, Transmission and Generation and compliance with technical, business, contractual, environmental, legal and regulatory criteria, such as compliance with the Transmission Grid Code and Distribution Network Code.
- *Master planning:* These are plans to determine geo-based loads for the next 20 years with the corresponding HV and EHV network requirements. Due to internal resource constraints and the need for long term network master plans, Eskom Distribution has a strategy for the completion of master plans with the assistance of external consultants. A national panel of approved consultants (with the ability to produce master plans) has been established, and master planning network areas have been prioritised.
- *Funding:* The initiatives mentioned in this paper have a significant funding requirement, and the support of senior management and stakeholders in obtaining the funds is essential.

Conclusion

The successful completion and implementation of the initiatives summarised in this paper are intended to make a quantum step change in the quality and effectiveness of Eskom Distribution Network Planning and hopefully the EDI. This will result in well trained planners, with the data they require at their fingertips, utilising systems and tools that enhance their effectiveness and assist in the implementation of guidelines and standards. This will be critical in future IBR environments where network reliability targets are linked to financial incentives and penalties. The benefit is intended to be realised industry wide, with IARC the main driver of skills development and knowledge transfer.

Acknowledgements

The authors would like to acknowledge the contributions of the TESCOD Network Planning Study Committee, working group members and leaders involved in the various initiatives, and in particular:

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- Sanjian Malapermal: Standards and Training
- Simphiwe Hashe: Load Forecasting
- Riaan Smit: Asset Utilisation. Δ

Overview of the approach and benefits in a value chain operational business

by Machiel Jacobs, Eskom

Organisations, such as Eskom operate in a rapidly changing environment. The need to change, environmental circumstances, innovative technology, the dramatic legislation changes all impact the electricity industry.

The fight to survive and adopting satisfactory customer services changed Eskom Distribution's focus during the beginning of the nineties from a functional organisation to a process driven business. The focus was on proving quality and good services.

To manage these on-going changes there is a need for accurate and up to-date systems.

It was and still is, recognised that failure to give a consistently high maintenance performance has a drastic effect on the productivity and profitability of any organisation. An equipped maintenance department, staffed with tradesmen, is finding itself inadequate for the demands of complex machinery. The levels of expenditure associated with the elementary maintenance work, demanded by the relatively simple machinery of decades ago, are rising, and management is faced with the challenge to reduce these costs.

During the past nine years the field services and network services business units have introduced improved work management methods, structures and supporting systems. The Distribution Group has implemented new processes, systems and infrastructure, and also captured and cleaned up massive data in order to improve the performance, and to cope with the increase in customer base. These processes run across the systems and functional boundaries, focus on adding value to the customer and ensure continuous business improvement.

Work management in the distribution business

Work management is defined as all those business processes together with their resources, infrastructure and supporting systems, with the specific objective to optimally schedule planned work and optimally dispatch resources for critical, unplanned work within the distribution business.

Work management is the co-ordination of fieldwork that leads to the effective utilisation and application of resources. Work management consists of business processes, resources, infrastructure and supporting systems.

The specific objective of work management is to optimally planned work and resources for work to be done.

The investment strategy for work management is to re-deploy a significant portion of the savings derivable from processes and systems into the distribution business. This strategy will consequently limit the scaling down of infrastructure, personnel or transport. Such redeployment would be absorbed into:

- Additional workload due to a growth in customer base
- Take-over of work done by contractors
- Increased preventative maintenance
- Collection of certain asset configuration information

It is also envisaged that certain cash flow savings may be realised in materials holding costs and in the safety insurance premium.

Work management directly supports the overall Distribution objective to provide electricity products and legendary service to customers in the most cost-effective way. Value chains and other information systems provide support for an organisation in achieving this objective.

Maintenance work management entails the effective matching of work demand with available resources, including, personnel, plant, information, tools, transport, infrastructure and spares. This environment is complex which results from ever-changing network, plant condition and customer requirements.

Catering for both field services and maintenance planning, work management is used on a daily basis by formal users and informal users across specific geographical areas on all work management functions for plant, i.e., scheduling for maintenance planned work and dispatching of repair tasks.

Work management recognises that the workload is increasing and that a specific intervention is required to avoid additional, future costs and to allow the business to cope with this increased workload to maintain the required levels of customer satisfaction and electrification targets.

Work management organisation

The guiding principle for work management is that all work to be performed within the Distribution business will either be dispatched or scheduled and there will be no other dispatching or scheduling done from any centre of work other than the Regional centralised work management centre.

The core business areas within work Management are therefore defined as "dispatching" and "scheduling". Both of these business areas receive work requests from other areas of the business, analyse the work content and priority, evaluate available resources, perform either a time or resource scheduling of these work orders and finally assign work orders.

There are fundamental differences between dispatching and scheduling.

The dispatching process will dispatch all unplanned work from the work management centre directly to the appropriate Technical service unit, technical specialist group that falls within the operational control of the work management centre. The dispatching process requires this centre to operate on a shift basis, 24 hour/7 days. Scheduling deals with all planned work requests requiring long term action. The difference therefore is that dispatching deals with work requests of high priority, criticality and urgency that are unplanned.

There are four key groupings within the dispatching business area. These are analysis and prioritisation, resource identification and assigning, work update and progress feedback as well as work order clearance.

The dispatcher is a role responsible for the complete start-to-end dispatching process. This role will thus include analysing and prioritising of work requests, the evaluation of available resources as well as assigning work orders. The dispatcher interfaces with various functions like fault management in the network management centre and customer contact centre, or direct with field resources in terms of specific work requests.

The scheduling process will schedule planned work from the work management centre to

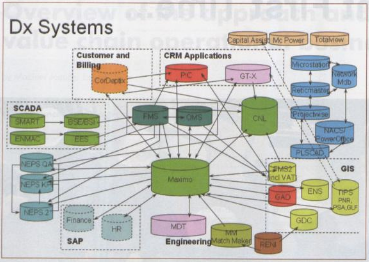

Fig. 1: Engineering software process.

the field services centre or technical specialist group that falls within the operational control of the work management centre. This scheduling operation will be within normal working hours and will not require shift work.

Macro scheduling on the other hand will only issue time scheduled work orders to a resource co-ordinator without assigning specific resources. This allows for micro scheduling where specific resources are assigned to each work order. These scheduling work requests and work orders are usually of bulk nature and issued at regular time intervals.

For the scheduling process, the performance will be measured according to the percentage of available man-hours actually scheduled via the system as well as the percentage of available man-hours actually applied to network related work. 'work scheduling' refers to those activities that will time-schedule work in an initial schedule. Should it be required to negotiate network availability or key customer acceptance, the initial time-schedule will be negotiated and changed if required. Once the time-schedule has been firmed the required resources will be scheduled according to the work to be performed. This resource scheduling will not be on an individual basis but rather per resource category.

The scheduler is a role responsible for the complete start-to-end scheduling process. This role will thus include analysing and prioritising of work requests, time scheduling of work requests as well as to issue bulk work orders to technical service centres and technical specialist groups. The Scheduler will be required to interface with various functions like maintenance planning, minor construction, customer relations processes as well as technical service units or technical specialists Groups in terms of specific work requests.

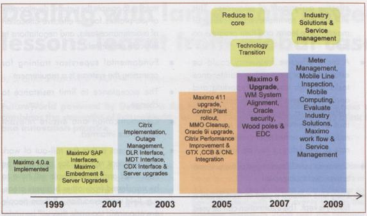

Fig. 2.: Software implementation and evolution.

The manager is the head of the work management centre. Both the dispatcher and scheduler role report to this management role. The key areas of responsibility for this role are to manage work management centre internal operations and resources, ensure business rules are applied and maintained, ensure scheduling and dispatching operations are optimally executed and to monitor work management business performance. This role is also responsible to manage internal and external contracts relevant to this business area.

As information is essential for both the dispatching and scheduling processes to perform optimally, the accuracy and completeness of all information in the system as well as the timeous capturing of this information is an important performance measure.

Core business support solutions

There are three main supporting systems for the work management processes; the work management systems, network management systems and geographical information systems. The specific computerised maintenance management system chosen for the Eskom Distribution Group was Maximo. The package was customised to cater for Eskom's requirements where necessary. The system is used by field services and network services to dispatch technical and non-technical work, schedule planned maintenance work, i.e. disconnection and terminations of services, meter audits and general maintenance of equipment. The system is also used to manage breakdown/emergency maintenance.

The work requests will in some instances be directly from interface systems to Maximo, specific with the unplanned type work. The functionality allows the scheduler and dispatcher to identify resource availability and to level resources according to work request requirements. The management and progress tracking of dispatched work are done via Maximo with the introducing of detailed milestone feedback statuses, these statuses are also used to inform customer on progress via the customer services building block. Resource, materials and equipment usage as well as effort and duration actuals are logged on Maximo for future estimates or reference purposes.

The release is also dependant on the information systems architecture components being implemented in order to execute specific work management applications. There are also critical integration points with the retail business.

The business architecture is a definition of all the business components that need to be deployed in an integrated manner to achieve the desired end-state of the work management business.

Interface concepts include:

- *Customer relations:* programme in order to receive work requests and provide feedback to customers on field work. (GTX and CorDaptix).
- *Mobile data computing device:* to minimise radio network usage and to ensure real time feedback on work.
- *Fault management:* the fault management system is for recording events which occur during network operations. SCADA and FMS.
- *Geographical information system:* the purpose is to provide physical location addresses of network equipment. Small world.
- *Maintenance planning:* they are responsible for providing optimal preventative maintenance work package by using Maximo.
- *Material management:* to achieve the business benefits of effective dispatching and scheduling, it is a prerequisite for effective access to the material management system to locate required material. Maximo and SAP.
- *Finance:* work management interface with the financial system in order to provide details of labour and material transactions taking place in the field, SAP.
- *Human resources:* to ensure correct date information is available, SAP.

Benefits of work management

The following describes the benefits from effective work management:

- It is anticipated that the correct resources and information to be assembled in a shorter time period, i.e. reducing search time and waiting time. This would result from the improved accuracy, completeness and timeliness of information when maintenance tasks are reported, executed and closed.
- There would be a significant improvement in the timely response to faults. An improvement in customer satisfaction is therefore envisaged.
- There would be an improvement in the effective assignment of resources. This will be due to improved tracking of maintenance teams and their progress on tasks.
- A more effective frequency could be established for preventative maintenance tasks through improved reporting and analysis of faults and equipment status. Deferment or expediting of tasks can thus be optimised. This will result in a reduction in unnecessary work and the rate of breakdowns can be improved.
- Customer service and image of the business is expected to improve
- Every time material is used on work orders a history is kept. This information can be used to refine minimum and maximum stock values accordingly, thus ensuring accurate stock holding.
- Better definition of expenditure to categories like insurance, planned maintenance and customer care, etc. is possible
- The single most useful benefit is the ability to measure and benchmark response to customer complaints.
- There would be a reduction in the effort to generate reports. This would mainly result from the reduction in duplicated and manual effort at various levels in the organisation
- Improved management information will be made available. It is expected that the timely, accurate and completeness of information will assist management to improve the planning, co-ordination and controlling of resources. Information which is common amongst divisions would be readily available on a national basis. This will include management as well as operational information, e.g. benchmarks, business plans, reports, plant specifications and work instructions
- Improved standardised processes will be supported by systems and will ultimately lead to an improvement in support functions such as training, job plan development and auditing

Lessons learned

During the implementation of work management process the following were encountered:

- Synergy with other systems and interfaces are important.
- Unavailability of acquisition, validation and conversion of the information about: plant data, customer information to point of supply, personnel information, transport information, materials information, GIS and GPS information, costing information, training to operate the systems, development of job profiles for the effective allocation of maintenance tasks, and negotiations to relocate personnel.
- Fundamental supervisor training for operating the systems is a requirement.
- The acceptance to limit resistance to change.
- Communication and ensure relevant people are informed.
- The concern is that the roll-out of work management requires the people to be appointed and these people will have to be transferred from other business areas, e.g. field work execution. If these people are appointed too early, they will be under utilised and create a bigger burden for fieldwork execution.
- Training is a major issue. Training plans need to be clear, who will be the training co-ordinator, who will perform the actual training or what training is required for the different roles.
- IT support after implementation.
- Development and enhancement budget. The perception is that too much funding is being allocated to the maintenance application and not enough funding to other applications, i.e. forecasting, providing for other work, etc.
- Alignment between enterprise architecture and business needs
- Different business performance measures do not necessary support full implementation of work management.
- To establish a work management identity
- The acceptance of the work management centre building block to execution for instructing work to be done by work order.
- Business had a culture of storing information on the back of a cigarette box, now there is a formalised process and system.
- Customisation never stops.
- Activity base costing can only be achieved with dedicated business discipline.
- Do not build an additional application without using the Maximo framework ie. Delphi application.
- Do not entrench business rules at database level ie. database triggers and stores procedures.
- Do not allow other applications to access database directly, but build regulated services.
- Do not build point-to-point interfaces.
- Ensure that the upgrade path stays sustainable. Δ

Dealing with large scale power emergencies: lessons learnt from global case studies

by Shamal Sivasanker, FutureWorld powered by Deloitte

FutureWorld powered by Deloitte is the focussed strategy consulting business of Deloitte Southern Africa. This business combines the strengths of FutureWorld - the global business and technology think tank - and Deloitte's South African strategy and innovation practice.

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Energy security of supply is probably one of the most topical subjects on a global basis, and one of the most talked about crises in the business world. As we see more constraints being introduced into global supply chains, impact of natural weather and the onset of climate change effects – keeping the lights on today is harder than it ever was. There are more large events that disrupt supply globally than ever before. When such events do occur, they strategically affect utilities, customers and have far reaching socio-economic impacts in their regions. South Africa is no different to having to deal with large events such as the Koeberg outage in 2006 and the national load shedding events of 18 January 2007. This paper focuses on some of the lessons learnt from other outages across the world; and how those utilities dealt with crises.

Lessons learnt from the global case studies

Globally, there have been several large incidents from which lessons were learnt in terms of management of emergencies. These would differ from the usual approach to management of outages.

In such conditions, there is usually a broader business mobilisation to manage such a crisis. Typically these will include:

- Strong stakeholder management.
- Strategic control of the situation through operations.
- Clear governance, decision making and accountability during the incident.
- Integration with the broader business community to keep them abreast of developments.

Examples from the outage in the Eastern US in 2003, Italy, London and Australia highlight learnings that are applicable in South Africa. Finally, how these lessons have been applied in the South African context can have a profound impact on how to manage an emergency in the electricity industry – to the extent that you can anticipate and become better prepared to ensure business continuity. Δ

Application of RCM type maintenance methodology within Eskom Distribution

by Peter Busch, Eskom

The implementation of a RCM (reliably centered maintenance) type maintenance strategy within the context of skill shortages. The equipment to be analysed being decentralised and the skills centralised. The results of centralised RCM studies being applied decentralised. A skills transfer of experienced staff to new staff. A successful implementation strategy for RCM strategies within Eskom Distribution.

The South African National Energy Regulator (NERSA) has adopted as part of its licensing requirement the following document, National Maintenance Policy for Electricity Networks NRS 082. This document states the following:

"The maintenance practice adopted for each plant item shall have been determined by a structured process such as RCM or similar and the results documented".

Eskom which is largest electricity utility. It has 5 divisions, which are the following: Generation, Transmission, Distribution and Eskom Enterprises and Corporate Services.

Eskom Distribution is divided into six Regions covering all of geographic South Africa. Each region is divided into a number of geographic areas where area staff makes use of a computerised maintenance management system to implement maintenance strategies. Within Eskom there is a lot of staff movement at this level and therefore a skill shortage exists and well as experience is in short supply.

There are approximately 4000 high voltage substations from 132 kV to 33 kV spread around South Africa. The substations contain approximately 4500 transformers with 99 different makes and types of tap switches. 45 000 circuit breakers of 400 different makes and types. 10 500 MV and HV lines. Eight different voltage categories are used from 132 kV down to 3,3 kV.

An initial pilot site for the implementation of RCM strategy was identified. Brackpan North a substation close to Johannesburg, was identified. The RCM study and implementation at the pilot site was done using the "pure" and traditional RCM methodology.

After the study was completed, the results of the study were compared to the normal maintenance strategy employed at the substation at the time and it quickly became clear that following the RCM principals would lead to a considerable maintenance cost saving during the life cycle of the plant without lowering and in most cases improving the reliability of the equipment.

The study of the pilot site itself took approximately four weeks to complete and included the local staff of the substation as well as equipment specialists for the various types of equipment found at the substation. This substation was close to Johannesburg where most of these skills are readily available keeping the costs of the study itself reasonable. By extrapolating these costs to remote and rural substations spread around the country it quickly became obvious that the cost saving achieved through following the pure RCM methodology was completely negated by the cost of the studies themselves as it would require specialist to travel to each site around the country.

With 4000 HV substations in the 132 kV. to 33 kV. category spread around South Africa and equipment specialists only being available in the bigger centres the time frame for implementation using traditional RCM concepts would be unacceptably long and impossible to achieve. The time frame would be in excess of 40 years.

A solution had to be found giving Eskom Distribution the advantage of using RCM as a maintenance strategy but simplifying the RCM analysis as well as simplifying the implementation.

With the skill shortages experienced within the geographic areas of Eskom distribution, the majority of the equipment decentralized, the equipment specialists centralized, a method had to be found allowing the inexperienced decentralised staff to use their local knowledge together with the knowledge of the centralised specialist to determine the optimum maintenance strategy.

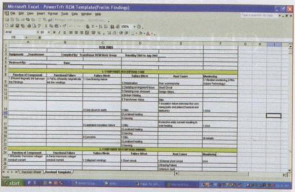

Fig. 1: Failure modes and effects analysis.

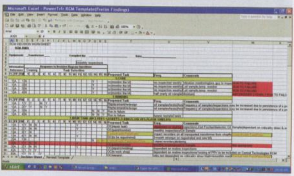

Fig. 2: Reliability centred maintenance decision diagram.

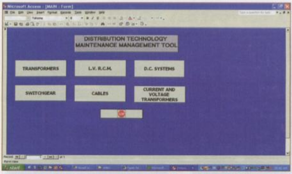

Fig. 3.: The Eskom Distribution maintenance management tool.

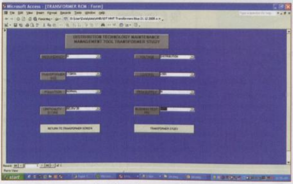

Fig. 4: Transformers input form.

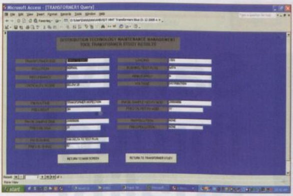

Fig. 5: Transformer results form.

As there had been previous unsuccessful attempts to implement RCM philosophies in Eskom Transmission and Distribution it was decided to run the implementation as an internal project.

The project consisted of the following:

- Identification of equipment to be analysised.
- RCM training of all staff involved in the RCM project.
- Managing of all work groups required for all RCM studies as well as time frames.
- Software data base development.
- Regional implementation of the RCM studies.

Equipment types were divided into various categories following the skills profiles of the specialists.

Transformers and tap switches, circuit breakers, DC systems, HV MV lines, cables, instrument transformers, isolators, LV etc.

Work groups were formed for each of the following:

The equipment specialists as well as all regional staff that were members of the work groups were sent on RCM courses so that all were aware of the RCM methodologies as well as failure modes and effects analysis.

These work groups were assembled at a centralised venue where they then analysed their respective equipment types using the RCM methodologies. Each work group contained equipment specialists as well as regional staff who knew the local conditions that equipment must operate under.

The FMEA (failure modes and effects analysis) as well as the RCM decision diagram which were done and recorded by the distribution transformer RCM. work group are shown in Figs. 1 and 2.

Their results had to take into account all possible scenarios where this equipment could be used around South Africa. These had to include all network variables, environmental variables, design variables, fault levels, etc.

For example; for transformers the following variables were identified:

- Whether the transformer had redundancy?
- What is the size of the transformer?
- What is the pollution level at the substation?
- What is the criticality score of the customers or load?
- What is the voltage level of the transformer?
- What is the loading of the transformer?
- Does the customer pay for a firm supply?
- Does the bushing have a test pin?

For tap switches the following variables were identified:

- Whether it is an on-load or off-circuit tap switch?
- What is the loading of the switch?
- Is it used in star or line end configuration?
- What type of design is the switch?
- What is the criticality score of the customers or load?
- What is the type of load?
- What is the make and type of the switch?

The work groups had to find a maintenance strategy for each of their identified possible scenarios under which the equipment could be operated.

The next challenge was to empower decentralised staff that does not necessarily have the RCM skill as well as not having the equipment specialist's skills to implement RCM methodologies.

The commercial software market was investigated for a suitable software package where the studies done by the specialists could be built into a data base to be used by decentralised staff for their maintenance strategies.

No commercial software package was found to be suitable for this application where the experience of specialists is built into the software package. The software packages that were available in the market all required the operator of the soft ware to have RCM skills as well as intimate knowledge of the equipment to be analysed. These were not suitable for the application required.

As Microsoft office is used as a standard software package by Eskom it was decided to write a software package in house using the Microsoft Access database program (see Fig. 3).

The program allows staff that does not necessarily have the equipment skill or the RCM skills to determine the maintenance strategies using RCM principles. All that is required is that the decentralised staff makes the necessary local condition choices and feeds these results via an input form into the database. A query runs through the tables and returns the result for which all choices made for the local conditions apply.

The returned results are the analyses which had been done by the equipment experts and regional representatives in the centralised work groups using the RCM principels.

The result contains the frequency whether time based or number of operations of every required maintenance intervention as well as a job plan number. The obtained frequency as well as the job plan number. is then inputted into the computerised maintenance management system.

The transformers table, for example, contains 576 variables that were populated by means of the specialists' RCM analysis results.

As the success of the project lies in the implementation of the software each region was visited by the implementation team. The software was explained and demonstrated to the regional staff. A software training program demonstrating the RCM program was also created and distributed to regional staff.

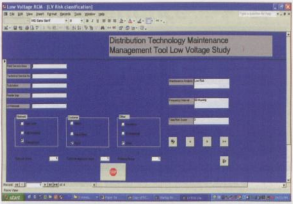

Fig. 6: Low voltage.

The implementation is monitored via the Maintenance Strategy Work Group.

An additional benefit of this project was that knowledge transfer between the equipment specialists' maintenance experience could be transferred to the maintenance planners via the software package. If equipment specialists should leave the company, their maintenance knowledge remains within the company as it is captured within the software package. Δ

Eskom's pilot national co-generation project

by Rob Higgo and Stuart van Zyl, Eskom

This paper describes the development history of the national co-generation framework that culminated in Eskom's Pilot National Co-generation Project. The objectives of the project and the draft timelines are presented. Grid Code requirements and some key technical aspects of the project are discussed.

During June 2006, Eskom's Executive Committee requested the organisation to pursue the development of co-generation as a supplement to South Africa's current non-Eskom owned and operated generation base.

After some consideration, an initial target of 900 MW of new co-generation plant has been established, and is proposed to be scoped, developed and to have reached commercial operation within five years.

What is co-generation?

A co-generator is a source of electrical power that is a co-product, by-product, waste product or residual product of an underlying industrial process. The Fieldstone Africa (Fieldstone) report [1] prepared for the National Energy Regulator of South Africa (NERSA) on qualifying principles for cogenerator projects stipulates three types of co-generators:

Type I: projects utilising process energy which would otherwise be underutilised 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 coproduct of an industrial process (e.g. use of bagasse and/or forestry waste from the sugar and paper industries).

Why co-generation?

Strategic reasons for pursuing co-generation include:

- Co-generation has potential to deliver capacity "quickly"
- Some co-generators may provide electricity at a lower cost than conventional generation
- Co-generation potentially reduces investment in networks and supports distributed generation
- Co-generation improves industrial efficiency and is environmentally friendly e.g. combined heat and power (CHP).

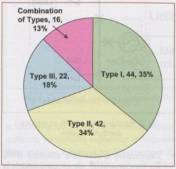

Fig. 1: Breakdown of EOIs received per co-generator type.

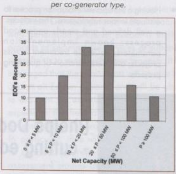

Fig. 2: Net capacity per project based on EOIs received.

Developing the "framework" for co-generation

One of the initial challenges that faced the Eskom business development team was how to go about creating an awareness of the initiative, coupled to generating sufficient support and interest.

Following discussions with members of the Energy Intensive Users Group (EIUG), a distributed/co-generation working group was established to work with Eskom, NERSA and industry in developing the co-generation frameworks necessary to promote co-generation in South Africa.

The first EIUG co-generation working group convened on 15 August 2006, under the chairmanship of Ian Langridge, Anglo's group energy efficiency manager. Key members of the working group include Anglo American, Anglo Gold Ashanti, SAPPI, Mittal, Sasol, NERSA, Fieldstone, BHP-Billiton, Mondi, Afrox, Highveld Steel, as well as other large power users and Eskom.

At the EIUG co-generation workshop held on 13 September 2006, Fieldstone presented feedback to the committee on the NERSA framework, coupled to additional information and ideas, generated during their interactions with Eskom and other large power users. There was commonality amongst members on the proposals, and a strong belief that the proposed framework would stimulate and support the introduction of larger scale co-generation in South Africa.

The "long term" framework was presented to the Eskom governance structures where it received "in-principle" support. A similar presentation was made to the NERSA Policy subcommittee on 14 November 2006 by the NERSA project manager, where the framework was considered, but not approved without additional work being required to meet approval criteria noted at the meeting.

With the potential delay introduced, Eskom, in conjunction with NERSA, set about identifying and designing a "short term" process to circumvent an excessively long approval process of the long term framework. This short term framework is now referred to as a "pilot project", as it will serve to be the forerunner of the long-term framework developed during 2006.

The principles and thoughts surrounding the pilot project were tested with members of the EIUG working group on 18 January 2007, where general support for the idea was obtained. The pilot project was then presented to members of NERSA on 19 January 2007, where overwhelming support for both the pilot, as well as the long term framework, was received. It was agreed that Eskom would continue to seek a mandate from its own governance structures in order to roll out the pilot project.

Eskom then engaged Fieldstone and an international legal firm, who have commenced working with the co-generation team in compiling the tender pack, and finalising the power purchase agreements (PPAs) in support of the frameworks.

A two day co-generation workshop was held with industry and NERSA on 13 and 14 March 2007 to deliberate on co-generation, the pilot project and the long term framework as well as the content of the PPA's being developed by Eskom. The workshop was well attended by industry, investors, project developers and key stakeholders.

The pilot project

Proposed framework

The pilot project that will enable Eskom's fast track approach to testing and evaluating the potential co-generation market is essentially designed on a conventional tender process.

The proposed framework, in summarised form, is as follows:

Stage 1 – assess interest in cogeneration: expressions of interest (EOI); developer evaluation; and notification of pre-qualification to bidders.

Stage 2 – bidding/tender process: bid enquiry issued; bid clarification; bid evaluation; and participant motification and awarding of contracts.

Stage 3 – implementation and delivery: participant monitoring of project implementation.

Key principles governing the process and scope of the project include:

- Developing the necessary tender documentation to attract new co-generation.
- Obtaining NERSA approval to contract the new co-generation.
- Developing a technical interconnection standard for co-generators.

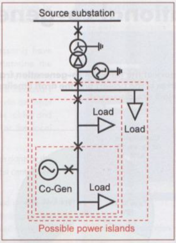

Fig. 3: Possible power islands on a radial distribution system.

- Developing a standard contract (PPA) for co-generation developers which is bankable.
- Having a transparent evaluation process to evaluate tender submissions. This includes: a well defined and clearly understood process; known implementation parameters; equitable treatment across projects; and determination of qualifying projects.
- Implementation of the process in a timely fashion.
- Development of a ceiling price which will be approved by NERSA (but not published) beyond which contracts will not be offered.
- Simplicity: procedural simplicity for projects to achieve regulatory approval; minimisation of transaction negotiations; and minimisation of transaction costs.

What is Eskom offering?

In the pilot project, Eskom is looking for approximately 900 MW of new co-generation to meet the following requirements:

- The co-generation must be newly built (i.e. new plant or re-commissioned plant offering new capacity). Refurbishments or upgrades to existing capacity are only eligible for the expected incremental capacity.
- It must be co-generation and not distributed or renewable generation that requires renewable energy grants (i.e. must be cost effective as a stand alone co-generator).
- The co-generator must be situated within South Africa
- The net installed capacity of the cogenerator must be at least 1 MW.
- The co-generator must reach commercial operation within five years.

The "lowest" bids will win contracts provided they are not above the ceiling price set by

Eskom's avoided cost model and modified by locational and timing (first on line) advantages. Maximum 15 year contracts are being envisaged with consideration being given to shorter duration contracts: seven years minimum duration.

Operational implementation of the pilot project is envisaged to include:

- Each developer bids a price and returns a signed contract (PPA)
- Bid prices higher than Eskom's avoided cost will not be considered
- A standard contract (PPA) will be developed for qualifying co-generation projects which is envisaged to include inter alia: payment profiles aligned with energy needs (supporting time-of-use/peaking periods; winter vs. summer etc.); and incentives for early completion
- A performance bond must be submitted in favour of Eskom to encourage timely development of co-generators.

Progress to date

An expression of interest (EOI) was dispatched to registered project developers and industry on 25 May 2007, and an overwhelming response was received. The results of the EOI are indicated in Fig. 1 (Types of co-generation) and Fig. 2 (Projected net capacity per project). Of the 125 submissions received, only one was rejected at pre-qualification stage, this a result of the fact that the generating plant did not qualify under the definition of a co-generator. approximately 4900 MW net generation has been pre-qualified, the individual plant sizes ranging from 1,8 MW up to 540 MW. Some duplication is, however, evident.

Looking forward, the draft implementation programme as at September 2007 is envisaged to be as indicated in Table 1.

Technical considerations

The implementation programme in Table 1 provides a five-month period for tenderers to complete their submissions. Part of the preparation will typically include obtaining a feasibility quote from the relevant supply authority for network expansion or upgrades that may be required to interconnect the co-generator to the utility network. Given the high number of bids expected, the short time frame, and the relative inexperience of Eskom Distribution staff when dealing with generation projects, Eskom is in the process of securing the services of suitable consultants to assist with these requests. It is envisaged that the consultants will be able to upport all Eskom regions, and will be able to draw on the experience of international experts in the field of co-generator and/or embedded generator interconnection. In particular, they will assist Eskom staff to conduct the relevant network impact assessment studies including: load flows, fault level calculations, and dynamic and transient studies (where required).

Grid- and distribution code requirements

Co-generation forms a subset of the broader concept "Embedded Generation". The draft Distribution Code [2] lays down a number of technical requirements with regard to embedded generation that will be applicable to the co-generation project. Not least of these are the requirements of the following sections of the Network Code (Draft Rev. 5):

Section 8.4.1.1(1): Embedded generators of nominal capacity greater than 10 MVA must comply with Section 3.1 of the South African (Transmission) Grid Code: Network Code [3] in addition to the requirements of the Distribution Code. Notable amongst the Grid Code requirements are the stipulation of the frequency vs. guaranteed operating time capability of the machine/s, and the requirements for governor and excitation control.

Section 8.2(4): The Distributor shall develop a protection requirement guide for connecting embedded generators to the distribution system to ensure safe and reliable operation of the distribution system.

Embedded generator interconnection standard

Eskom is currently drafting an embedded generator interconnection standard in fulfilment of the Distribution Code requirement, and as an input into the co-generation tender process. Some of the key technical issues included in the standard are described below:

Loss-of-grid protection

Embedded generators are normally not permitted to intentionally island with a part of the utility network. On radial networks typical of distribution systems, the opening of any circuit-breaker between the source substation and embedded generator's point of connection may serve to create an unintended power island (see Fig. 3). The reliable and secure detection of such "loss-of-grid" conditions remains one of the key challenges with regard to embedded generator interconnection protection.

Where required, dedicated loss-of-grid protection typically takes the form of a rate-

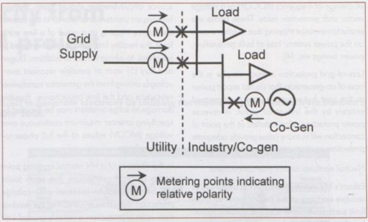

Fig.4: Conceptual metering arrangement for a co-generator embedded within an industrial plant.

Activity	Target date
1. Expression of interest	Completed
2. Request for Tender(RFT)	
• Approval to issue draft PPA to market.	27 Sept 2007
• Issue RFT and draft PPA to pre-qualified bidders.	30 Sept 2007
• Bidder's clarification conference.	Week of 5 Nov 2007
• Updated draft PPA released to bidders.	End Nov 2007
3. Bid submission.	Mid Feb 2008
4. Bid evaluation completed.	April 2008
5. Final recommendation on PPA's to be offered	April 2008
6. Approval to sign PPA's obtained from Eskom Board	June 2008
7. Successful bidders notified.	June 2008

Table 1: Draft implementation programme (as at September 2007)

of-change-of-frequency (ROCOF) or a voltage vector shift protection relay. These relays are prone to nuisance tripping due to other events on the power system: loss of bulk generation, power swings etc. [4].

Loss-of-grid protection is much simpler in the case of co-generators that do not export power to the grid but whose output is consumed entirely by the industrial plant. A reverse power protection relay installed at the point of connection will in many cases provide adequate protection against unintentional islanding.

Neutral earthing on MV interconnections

Eskom's MV distribution networks make use of resistive earthing of the neutral point so as to limit earth fault currents to the typical ranges: less than 720 A (rural networks) and less than 1600 A (urban networks).

The preferred neutral earthing philosophy for MV-connected generators or generator transformers is that the MV neutral point be left un-earthed. This will serve to avoid issues of earth fault relay de-sensitisation, as well as avoiding "circulating" zero sequence or triplen (i.e. 3rd, 6th, 9th etc.) harmonic currents between the distant earth connections.

A possible problem with leaving the MV starpoint un-earthed is that the MV network will be left un-earthed in the event that the source circuit-breaker should open, thereby forming an unintentional island. In the case of the source tripping as a result of a line earth fault, the healthy line voltages will be raised to full phase-to-phase values. In addition, Dugan and Rizy [5] warn of possible resonant over-voltages arising from the generator transformer reactance and the line capacitance. Possible damage to surge arresters may be avoided by specifying arrester maximum continuous over voltage (MCOV) values at the full phase-to-phase voltage.

In the absence of a MV neutral earthing point at the point of connection, line earth faults will be detected by residual over-voltage protection. It must be ensured that the residual over-voltage protection is suitably graded with the current-based earth fault protection used in the distribution network.

Metering

Co-generators will be remunerated for energy delivered to the network at their bid price. Any power drawn by the plant (e.g. generator auxiliaries, other manufacturing processes etc.) will be billed at the standard load tariffs. This creates the requirement for the power generation to be metered at the generator terminals. The "load" charges for the plant will be calculated from the sum of the meter readings at the existing demarcation between the utility and the plant, and the generator meter readings (see Fig. 4).

The utility will own and operate all tariff meters. The location of some meters deep within an industrial plant may create problems with regard to security. Access problems may be overcome using remote meter downloading technologies.

Conclusion

Eskom has embarked upon a pilot project that aims to connect approximately 900 MW of new-build co-generation within the next five years. The pilot project is a result of a lengthy process involving Eskom, NERSA and many large power users that sought to develop a framework in support of co-generation in South Africa.

An expression of interest issued in May 2007 yielded 124 pre-qualifying responses totalling some 4900 MW net generation. Individual plant sizes ranged from 1,8 MW to 540 MW. The process going forward is essentially designed around a conventional tender process. Only tenders whose bid price is below the (unpublished) Eskom avoided cost will qualify for contracts.

Eskom is presently finalising the power purchase agreements and technical specifications in support of the pilot project. The latter takes cognisance of the requirements of the Distribution- and Grid Codes, as well as addressing a number of technical challenges including loss-of-grid protection, and earthing and metering requirements. Eskom will be engaging consultants to assist with the technical impact assessment studies associated with each co-generator project.

Acknowledgement

The authors gratefully acknowledge the contributions of Francois Viljoen (project leader for the Eskom co-generation pilot project) and Hendri Geldenhuys (Eskom corporate consultant) in commenting on a draft of this manuscript.

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Durban's electricity from landfill gas CDM project

by R Wienand, eThekwini Electricity

The first phase of the multi million rand project to generate electricity by utilising the methane gas released from Durban's garbage landfill sites went live in December 2006.

With the environmental impact assessments complete and a positive Record of Decision (ROD) received, the project received the blessing of the Designated National Authority (DNA) in the Department of Mineral and Energies (DME), and was registered with the Clean Development Mechanism (CDM) executive board of the United Nations Framework Convention on Climate Change (UNFCCC). Durban was proud to turn on South Africa's first (CDM) landfill Gas to electricity project.

The project is aimed in the first instance at addressing global warming and climate change which is one of the most serious environmental issues facing the world today. The recent ratification of the Kyoto Protocol, by numerous governments worldwide, is a significant step towards cost-effectively reducing greenhouse gas emissions and averting impacts of climate change. According to the Kyoto Protocol, methane (CH_4) is a listed greenhouse gas (GHG) and its effect is some 21 times worse than carbon dioxide. It is widely known that landfill sites, with wastes undergoing a methanogenic stage of biodecomposition, produce large volumes of landfill gas (LFG) typically containing some 40 - 60% methane. For many years Durban has been doing limited "flaring' of methane from these sites to reduce the risk of uncontrolled fires, and to control odours.

Since landfill electricity-from-gas generation projects are currently not competitive with local electricity costs - being about 66% more expensive than current Eskom figures - the project is made possible through "Carbon Finance" which for the first phase of the project is channelled through the World Bank's Prototype Carbon Fund (PCF), a public private partnership with participants from several countries worldwide. This recently available carbon finance – accessible since South Africa's signing of a host country agreement allowing for the acceptance of CDM projects - has made it possible for financially viable landfill gas utilisation projects to be developed on the African continent.

The proven method of extraction of the landfill gas through pipe work systems from the landfills allows the gas to be fed into the purpose-built spark-ignition engines. On the Marianhill site a 1000 kW machine was installed. The site was sized to accommodate a second engine which will only be commissioned when additional gas wells are installed in newer zones which are still receiving rubbish on a daily basis. At LaMercy a 500 kW machine was installed. As this site is already closed to new rubbish the gas production is limited.

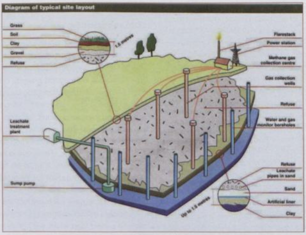

Fig. 1: A typical arrangement for a landfill site power generation scheme.

Methane is "the petrol" to this power generation process and carbon dioxide will be emitted as exhaust gas. This project is aimed at the destruction of methane in engines and is proven to be greater than 99% effective. In addition there will be significant emission reductions by way of the reduction in Durban's electricity demand from Eskom by up to 10 MW when all three sites are fully operational. This project will reduce some 450 000 tons of carbon dioxide which would have been emitted by Eskom's power stations over the project life span of the sites. In total, the project is expected to reduce equivalent emissions in carbon dioxide to our atmosphere by 3,8 million tons!

While it is not part of the current financial model, an additional source of income could be from the sale of "green electricity" at a premium, generated from this project. Countries that have highly developed environmental laws and policies are starting to ask South African companies who export their products how environmentally clean their production is. Electricity is one of the inputs to production, and these SA companies may be willing to pay a premium for electricity generated from a clean or renewable source.

Technical issues

Durban has no local generation and buys all its electricity in bulk from Eskom at 275 kV, and distributes it to customers via its network of 275, 132, 33 and 11 kV cables and overhead lines.

When an opportunity for locally distributed generation is presented, it is not a simple case of connecting into the nearest overhead line or cable. System stability, voltage regulation and other quality of supply issues must be carefully analysed and this is a subject on its own requiring professional system analysis. Local system constraints will occur at low consumption times over weekends and late at night. Unfortunately the landfill gas is produced at a constant rate and short of spending additional capital to build gas storage facilities, the gas must be used continuously as it is produced by the landfill site. The challenge is to accommodate the generation 24 hours per day seven days a week without causing localised system instability. Complex protection schemes are needed to monitor power flow and trip the generators when primary supply from the network is lost, to prevent islanding of the generator and a part of the network.

Both projects have provided a steep learning curve for the team of civil and electrical engineers. The main contractor for both sites was Envitec Solutions in a consortium with Construction and Plant and Organics Ltd. The engineer was Enviros Consulting with Wilson Pass Singh jv as a sub consultant. The GE Energy Jenbacher JCG 312 GS-L.LI and JGC 320 GS-L.L units are state-of-the-art, and when used in stand-alone "island" type installations require very little on site electrical engineering to get them up and running. The first challenge came when Durban's local 11 kV Network was found to be causing unnecessary tripping of the 11 kV breaker feeding the generator, when remote earth faults were detected. After many technical discussions between the protection staff at Durban Electricity and the Genbacher experts it was decided to install neutral earthing resisters on the star point of the 440/11 kV delta/star generator transformer. In simple terms every time a distant remote earth fault happened in the network the generator protection relays assumed that the local 11 kV circuit directly connected to the generator substation had an earth fault and due to the speed of the local protection would incorrectly disconnect the generator. In the meantime the remote 11 kV circuit which did have the earth fault had also been disconnected and the rest of the network, including the supply to the generator had remained on. These false trips then required 11 kV authorised field staff to visit the site and close the breaker. The generator would then re-sync to the network automatically as designed after an outage.

The second lesson learnt was that gas supply for these engines requires a greater degree of monitoring and control then had been necessary with the simple flaring done in the past. Methane needs to be approximately 50% and oxygen needs to be kept below 5% of the total gas input for safe and efficient operation. While all the initial calculations had shown sufficient gas at Marrianhill site to supply a 1 MVA machine, in the first three months it was found that the gas supply was unstable. If too much gas was "sucked" from the field the oxygen level rose above 5% and the machine tripped on gas safety. The 1000 kVA generator then had to run at 600 kVA for the first four months to allow the gas field to stabilise. This output has now been increased to 900 kVA and the site will be closely monitored. At the LaMercy site the gas was found to be too "wet" and engine performance is very erratic. Additional civil works on the gas wells has been done and it is expected that this site will start producing sufficient good quality gas soon and the engine can be used. Up to now the gas have been flared. While carbon credits are still earned from flaring, the income from electricity generation is lost, as well as income from carbon credits due to avoided generation by Eskom is also lost.

CDM registration.

For anyone thinking of starting a CDM project the administration issues are substantial. The first point to note is CDM will not turn a "poor" project into a good project. The basic engineering fundamentals must be sound. CDM is only an additional source of revenue which can be used to make a sound technical project financially viable. The administration burden both in terms of human resources and cost must not be under-estimated. There are a series of administration steps which must be followed and to date there is no short cut. As projects like this become more routine this burden should reduce, but for now each project still needs considerable admin resources. Once you have a sound project idea which will clearly mitigate CO_2 emmissions in line with the CDM rules the first step is to submit a project idea note (PIN) to the DNA at DME. The PIN should not be more then a few pages fully describing the project, the CO_2 savings and a financial business plan. The DNA staff will provide guidance in the next step which is a full Project Design Document (PDD). Depending on the type of project the PDD can be 40 to 50 pages and is required by the CDM executive board. All applications for registration of CDM projects world-wide have their PDDs published on the UNFCCC's CDM website (www.cdm.com) for public comment, and this is only after an independent "validation". Only after this process, and following support from the host country's DNA, and subject to positive ROD's in any EIA required, will the CDM Executive Board (EB) consider and hopefully approve and register the project. The above process is a mouthful just to read. It is a long, costly and sometimes difficult process for someone doing a CDM project for the first time.

But the admin challenge story does not end at CDM registration. Once your project is up and running you can't simply claim carbon credits and expect a cheque. In February 2007 a world bank (i.e. our CER's buyer)-appointed CDM audit/monitoring team visited Durban for a week. Both sites were fully audited. With the exception of some minor admin items both projects received full CDM "certification". Durban can therefore now invoice the world for the first six months of carbon credits which will form the bulk of the income. An average of 420 000 kWh of electricity was generated at the Marrianhill site per month, which at Megaflex summer rates has saved Durban approximately R50 000 per month on our Eskom Bill. This figure went up to R75 000 per month when Eskom's Megaflex winter rates were used in June, July and August. The LaMercy site generation was still experiencing gas quality problems so generation was limited and most of the gas had to be flared. The CDM credits are still subject to CDM audit and were not available at the time this paper was completed.

Fig. 2: Durban's Marianhill landfill site showing the new generation station.

Summary

Durban is very proud of the first phase of a project which has taken over five years to see the light of day. It has been a very long road with many lessons learnt. Global climate change is a critical issue facing our planet so we need many more CDM projects, but anyone wanting to go down this road needs a great deal of patience and determination. The red tape and admin costs are very much higher than first anticipated. The engineering was relatively simple. The EIA's and the admin necessary to comply with the CDM financing was a huge challenge. Without a dedicated and passionate project champion and the full backing of your council and city/town manager/company CEO it will be all but impossible. In Durban's case Lindsay Strachan from our solid waste department was that champion and the project had the full backing from the mayor and city manager. Credit must also go to Andrew Gielink from the Electricity Department who taught the international consultants a few tricks. We plan to commission the first 4 MVA out of 8 MVA at the Bisasar Rd site in early 2008. Even with all the experience picked up on the first two sites we continue to learn new tricks every day which should help us for the next phase.

Anyone wishing to discuss various aspects of the project should telephone Roy Wienand from eThekwini Electricity, Tel 031 311-9003, wienandrf@elec.durban.gov.za Δ

Renewable energy sources to address security of supply in South Africa

by Vally Padayachee, City Power Johannesburg

Mounting evidence of climate change and the concern over the sustainability of deriving energy from finite, carbon based resources that are being consumed at an exponential rate, has focussed the world's attention on energy efficiency and conservation as well as a quest for large-scale utilisation of renewable and regenerative energy sources.

These issues have not escaped the attention of the South African government:

- The White Paper on renewable energy (November 2003), set a target of 10 000 GWh renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar and small scale hydro.
- The renewable energy is to be utilised for power generation and non-electric technologies such as solar water heating and biofuels.
- Electricity Regulation Act, where, amongst others, the objectives of the Bill include: the efficient, effective, sustainable and orderly development and operation of the electricity supply infrastructure in South Africa; and promote the use of diverse energy sources and energy efficiency.

These initiatives are driven by several important objectives:

- To "clean-up" the energy environment in terms of CO_2 emissions
- To preserve mineral energy resources for future generations
- To improve the security of the electricity supply

This paper is intended to explore the degree to which renewable energy sources can be expected to contribute to the last objective – electricity supply security, in the South African context.

Background

In the electrical energy sector, there are complex, time-related aspects that have an impact on the security of supply – presently the industry is characterised by both generation capacity and distribution network capacity constraints at all levels. This landscape will persist in the medium term as new generation plant and distribution infrastructure upgrades undergo construction, while a continued load growth of 3,2% per annum is expected.

The national generation reserve margin fell to below 7% in 2006, where the international norm to mitigate generation outage risks considers a margin of 15% necessary. In response to this deficit, Eskom in conjunction with municipal distributors have implemented load shedding plans to maintain an acceptable reserve margin in the event of generation emergencies.

This drastic measure, even of short duration, has a devastating impact on the economy and is used only as a last resort. It is anticipated that the load shedding plan will be in effect for the next five years.

In order to minimise the economic impact of forced load shedding, it is incumbent on the power distribution industry to execute such load shedding as deep into the network as possible, assigning priorities and discriminating between interruptible, non-essential, industrial, commercial and essential load circuits as far as is practically possible. This process can be automated by SCADA systems where such are installed, and in the eventuality that load shedding is required; such automation investment can quickly be justified.

There is a strong focus on energy efficiency and demand side management interventions (EEDSM) in the industry at present, supported by the DSM funding mechanism and targeting load reductions in the order of 3000 MW by 2012.

The scope of this funding, originally focussing on direct electrical efficiency and load shifting interventions has been expanded to include an ambitious solar water heating system, targeting one million installations over a five year period.

Renewable energy sources - part of the SA generation portfolio?

Without a means to store energy in the volumes that is required, the intermittent characteristic of particularly wind and solar energies will always place them at a disadvantage compared to hard, fossil fuel-fired sources. In the northern hemisphere, both of these technologies are considered to make an independent average contribution of only 13 to 17% of their installed capacity towards 'reliable' generation capacity.

It is likely that in South Africa, a similar contribution can be expected from wind sources. In terms of solar, the average figure is likely to be significantly better, as we have one of the highest solar insolation levels in the world. The problem however, is that there are on average 56 'overcast' days per year, in which case it is still expected that conventional electrical energy will be available to provide supplementary energy for water heating purposes, for example. The worst case scenario would be a large weather front covering the entire South African sub-continent for a few consecutive days.

This would add additional weather sensitivity to generation scheduling, and on these 'bad solar' days, generation capacity more or less equal to the capacity of the solar driven apparatus would be required at least as a 'reserve'.

So, do intermittent renewable sources alleviate or exacerbate reserve margin requirements? A key issue is to ensure that a diversity of renewable sources are included in the mix, and that the renewable plant is geographically well spread out. For example, wind sources complement solar sources to a large degree – overcast days are usually accompanied by windy conditions, and in general, overcast conditions in the Cape often do not extend to the Highveld regions.

Experiences of countries with significant renewable resources

Germany has a significant proportion of installed wind turbine plant – a total of some 20 GW, where the national peak demand is in the region of 75 GW. It is not only the lack of wind that determines the intermittency – at the other extreme, too much wind requires that the plant be feathered to avoid damage, or reduce the back feed of power on the limited capacity rural networks opportunistically used to connect the plant to the national grid.

Wind conditions can change drastically within half an hour, and to ensure sufficient backup generation is available, a large proportion of coal-fired spinning reserve has to be maintained, in addition to fast reacting gas-fired plant. When asked about the complexities of generation scheduling in this environment, it was pointed out that the industry was getting very good at short term weather forecasting as a result – down to intensely focussed half hourly predictions when necessary.

New Zealand's approach has been to embrace wind energy to a large extent, strongly complemented with hydro resources, where such sources have sufficient storage capacity.

It has previously been noted that the South African generation portfolio is short of gas turbine peaking plant. Significant investment in OCGT plant is presently under way and, in the context of expanding renewable sources, will not become a stranded investment once additional base load generation is brought on line.

Solar water heating systems – distributor perspective

Large scale implementation of solar water heaters will inevitably result in significant revenue loss, but will also on average alleviate the load on the distribution network. The issue is that the supplementary energy requirements on bad solar days will still require a network designed for conventional geysers, and these networks will still need to be maintained, less a large portion of the revenue derived from this type of load.

These risks can be mitigated to a large degree by ensuring that limits are placed on the electrical element size, reducing the standing losses by improved insulation, correctly sizing the storage tank and utilising existing, centralised geyser control systems to specifically control the provision of supplementary energy to the mutual benefit of the distribution utility and the end-user.

Revenue loss can only be offset by utilities becoming directly involved in the implementation of solar water heating systems, either directly as a pay for service hot water supply utility or by offering maintenance services coupled with collective application of installed solar plant to earn CDF revenue.

Renewables – challenges

The renewable energy industry is in its fledgling stage at present, and faces several challenges:

- Funding sources and mechanisms
- Capacity to supply and install equipment
- Viability – top-up or feed-in tariffs for renewable energy, based on levies taking into account the production costs of the various sources
- Sustainability - an investment in a coal-fired power station would be specified to have a lifespan of at least 20 years, and the same should apply to renewable equipment, for example solar water heating interventions.

Recommendation of the way forward - renewables

A diversity of sources must be considered:

- Wind resources
- Landfill gas opportunities
- Solar street lighting and traffic signals
- Hydro – small and large opportunities
- Wave energy – search for viable technologies

Conclusion

Is the above sufficient to mitigate security of supply risks?

If the answer could be no – then it would be prudent to do a re-examination!

On the other hand, when would be a good time to make a start? Δ

Do you manage your assets?

by Paul van Niekerk and Jaco van Niekerk, EON Consulting

The electricity distribution industry (EDI) in South Africa has three distinct groups of players, Eskom, the Metropolitan Councils and a multitude of municipal distributors that each face a set of unique asset-related challenges.

These challenges include amongst others:

- An aeging network compounded by poor maintenance procedures.
- Rapid growth in demand and geographic expansion.
- Overloaded infrastructure with limited redundancy.
- Limited capital investment in past five years due to the growing uncertainty in the industry.
- Higher cost to maintain and operate the networks effectively.
- Poor maintenance practices leading to outages and negative public perception
- Availability of qualified and experienced resources to manage / maintain network assets.

The national government's initiative to restructure the electricity distribution industry into regional electricity distributors (REDS) will have a positive impact on service delivery in the country. The impact of restructuring of the industry on service delivery will be minimised by implementing the basic principles of good asset management consistently throughout the industry.

The internationally accepted best business practice of enterprise asset management (EAM) was introduced and adopted by key utilities in South Africa from the late 90s. However these practices are perceived to be time-consuming, complex to manage and require dedicated resources to create sustainable value to the utilities business. The critical resources required for EAM include: skills (people), mature operating practices (processes), information systems and mobility (technology) and accurate, up-to-date network equipment data (asset content).

Due to perceived complexities, not all the utilities have adopted the EAM practices. This leaves room for improvement, in preparation for consolidation of the respective wires businesses through EDI restructuring. This paper will explore a simplistic approach to managing network assets effectively. We will define the approach, based on PAS 55, the respective organisational roles required in the wires business, and provide pointers on how to establish and improve an EAM system.

Definition of asset management

Enterprise asset management is a pragmatic approach to managing an organisation's assets across the enterprise, to achieve its strategic goals while providing tools for making decisions which allow a utility to meet a required standard of service in the most cost-effective way.

Thus, asset management encompasses the strategies, technologies and processes to optimise lifecycle value contribution from an asset or portfolio of assets.

Effective asset management is all about the optimisation of :

- *Physical assets:* ensuring that assets operate at designed parameters with optimal, off-normal operations.
- *Life cycle costs:* optimising initial and ongoing investment to extract the maximum operating and financial value from the asset over the course of its lifecycle
- *Resources:* maximising the contribution from those who manage the asset through review and assessment of physical and personnel performance against key measures
- *Risk:* balancing engineering, operational and financial risk of the assets with expected return.
- *Asset value source:* developing alternatives sources of value derived from physical assets, management and operations competencies and/or financial engineering.

The standard of service not only relates to reliability but also to supply capacity availability, and should provide the following long-term benefits:

- The financial results of the utility can be improved due to the extension of the useful life of assets.
- The technical performance of the network will improve due to the improved planned maintenance.
- People will be more productive as a direct result of improved planning and better targeted human resource development.
- The organisational efficiency will increase due to improved and optimised business processes.
- Decision-making will be improved because better information will be available with respect to infrastructure, people and processes.
- Cost of maintaining network assets will decrease over time, also resulting in a much more effective workforce.

Who is involved in asset management

Asset management is the optimal management of assets to deliver the required level of service, to achieve the best or most appropriate trade-offs between competing factors such as performance, costs and risk.

In the municipal environment this refers to the dichotomy of the relationship between the engineer's desire to maintain assets and the financial manager's desire to limit fruitless expenditure and the client relationship manager that has a relentless passion to service clients professionally.

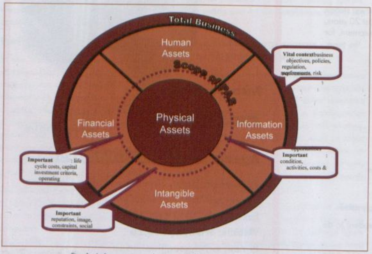

Fig. 1: A diagrammatic description of an asset centric business such as an electricity utility. (Diagram from PAS-55).

The whole organisation, including the senior management illustrated in Fig. 1 should be involved in the asset management programme, as it will impact on the full business process of an asset-centric organisation.

- The board of directors or the council's executive committee
- The chief executive or managing director of the organisation
- The chief information officer
- The chief financial officer
- Maintenance managers
- Maintenance staff.

The retail business (customer services division) being separated from the wires business (assets management division) as the organisation is based on a "split wires and retail" concept. The asset manager however will provide a service to the customer services manager in connection with the connection of new customers and common issues of planning and system reinforcement.

There are three distinctive roles that need to collaborate in harmony to bring about an asset management organisation. Each of these roles has a unique set of responsibilities to ensure that asset management is enforced, sustainable and ultimately create business value. These roles are:

- *Asset owner:* The asset owner is the licence holder, equity participant and investor that holds the portfolio of assets and set and manage performance requirements for each.
- *Asset manager:* The manager is the asset steward, has a reliability focus, plans and monitors the operating activities carefully. The asset managers make fact-based decisions on optimising customer needs, operational status and financial returns. Managers are key to delivering value to all stakeholders.
- *Asset operator:* The operator is the work manager, has a strong cost and service excellence focus and performs physical activities. The operators are order fulfillers and data suppliers.

The challenge that a lot South African utilities face is that these roles above are overlapping, is not clearly defined and most of the time not exist. We believe the key to effective asset management is the dedicated asset manager role, that will be responsible to realise the benefits defined above. This role is currently not well defined, and can make a huge impact, on all the utilities in SA.

What is asset management?

The critical elements of a business are those that are required to deliver a utilities' business mission, strategy, policies and objectives.

For the purpose of asset management, these critical elements have been summarised into five categories as follows:

- Physical assets (electricity transmission and distribution infrastructure, machinery, plant, and equipment, buildings, IT systems).
- Human assets (management, workforce, skills and experience).
- Financial assets (cash, investments, equity, credit rating).
- Data (data, information, and knowledge).
- Intangible assets (customer service reputation, customer and staff impression, public image/relations, brand value, NERSA licence, copyrights and culture).

In any physicalasset-intensive business, such as the electricity distribution industry, the greatest expenditure, effort, dependency and risks are invariably associated with the physical assets:

Although the other four families of asset types are also critical and require appropriate consideration, they are considered only insofar as they affect the optimal management of the physical assets:

- The behaviour, attitude and capabilities of the workforce have a fundamental influence on the performance of the physical assets.
- Good quality data/information/knowledge is essential to develop, optimise and implement asset management plans.
- Financial resources are required for infrastructure investments, operation, maintenance and materials.
- The organisation's reputation and image can have a profound impact on infrastructure investment and operating strategies and associated costs.

The elements of asset management

For an electricity utility, the distribution infrastructure is required to provide a continuous and permanent supply to its customers, and hence the asset management is based on a permanent service to customers and therefore continual improvement of the distribution infrastructure.

The illustration (Fig. 2) taken directly from PAS-55 illustrates the critical elements of an asset management system.

The organisation should establish, document and maintain an asset management system in order to collate and record credible information about the assets.

- The senior management of the undertaking should authorise an overall asset management policy which is consistent with the organisations strategic plan.
- The organisation shall establish and maintain an asset management information system in order to provide credible information about assets, and provide adequate support to management and staff.
- The organisation should establish an organisational structure that clearly defines management practices for all asset classes and incorporate them into asset management planning.

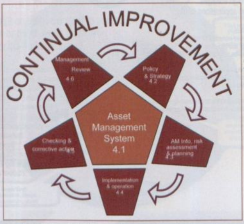

Fig. 2: The critical elements of an asset management system. (Taken from PAS-55).

- The organisation should institute measures to ensure a proper feedback mechanism to provide corrective action and continually improve/optimise asset management practices.

Asset management process

The process of asset management is one of 'continual improvement' as illustrated in the PAS-55 document

In terms of PAS-55, the organisation's board of directors should instruct top management to implement an asset management system. The board must then approve the policy and strategy proposed by the management team.

Strategy and policy

Asset management (AM) involves the co-ordination of activities that manage the organisations' assets over the full lifecycle of the assets for the achievement of organisations business objectives. This alludes to optimally managing these assets in terms of performance risk and expenditure.

Good asset management therefore begins with the board, or council approving the policy and strategy which will then permeate throughout the organisation and eliminate the dichotomy which often develops between financial and engineering managers that have different ideas about what asset management really is.

Next would be the establishment of an asset management framework that will operationalise the strategy by integrating the AM requirements into the key related business processes.

Asset management information, risk assessment and planning

PAS-55 stipulates that the organisation shall establish and maintain:

- An asset management information system
- Risk identification, assessment and control
- Legal, regulatory, statutory and other asset management requirements
- Set and maintain asset management objectives
- Asset performance and condition targets
- Asset management plans

In order to introduce lifecycle management of assets, the system would control asset procurement and registration in terms of the approved financial policy and immediately schedule and track to ensure that its use is optimised in terms of the maintenance policy.

Checking and corrective action

PAS-55 states that the organisation shall establish and maintain procedures to monitor and measure the performance of the asset management system (processes)

In South Africa up until now, NERSA has been fairly lenient with the application of the quality of supply standards [NRS 047 and 048]. However this will change with the establishment of the REDS and distribution utilities will be held to task regarding quality of supply. It is essential therefore that the AM systems should be carefully monitored to ensure compliance with company policy.

The same methodology could be used for forensic investigations to determine reasons for the failure of assets.

Management review and continual improvement

The organisation's senior management shall review the asset management systems and processes from time to time to ensure suitability, and confirm the information integrity, and verify that AM techniques are modern and relevant to the organisation

The management review should address the possible need for changes to the policy strategy and objectives and other elements of the management system in respect to changing circumstances and the commitment to continual improvement.

In a municipal environment, the changing circumstances may be due to city planning variations such as modifications to the integrated development plan, or rezoning. To quote an example, the 2012 Soccer World cup or the Gautrain development may force major redesign of the city infrastructure, and hence changes to the asset management policy. Other changes may include the establishment of the REDs which will change the management and staff of the organisation.

Asset management information, risk assessment and planning

Asset management information system

PAS-55 The organisation shall establish and maintain an asset information system which shall be designed and maintained to provide adequate support and information to the organisation to meet the strategic plan.

An asset information system is essential for achieving effective and efficient asset management processes and for continual improvement of the system.

There are several different types of asset information systems available, and the more sophisticated versions integrate many of the following functions which are essential to sound asset management practices:

- Asset registers
- Document management systems
- Work management/programme planning and scheduling systems
- Materials management systems
- Purchasing systems
- GIS geographic information and spatial analysis systems
- SCADA, or interconnection to existing SCADA systems
- Condition monitoring systems.

An asset management system should provide both technical and financial information in order to facilitate choices in respect of:

- Lifecycle cost comparisons - how much does one spend on an asset before replacing it?
- Financial benefits of planned improvements
- Valuation of assets NPV DRC etc. (for acquisitions and mergers)
- Identify the physical position of the asset (GPS coordinates)
- Comply with statutory and regulatory obligations (NERSA)

Risk assessment and planning

PAS-55 - The utility shall establish and maintain procedures for the on-going identification and assessment of asset-related risks and the identification of suitable control measures.

The risk assessment shall consider the probability of the event occurring and the severity of consequences.

It is incumbent upon a well-managed utility to ensure that all risks are well-managed during the full life cycle of the asset to ensure continuity of supply. Such risks shall include

- Risk of physical failure of the asset.
- Operational risks including control of the asset, human factors, malicious damage or terror activities.
- Natural environmental risks (flood and storms, etc.)
- Asset related design, specification procurement and construction, operation and maintenance during the lifetime of the asset, and finally decommissioning and disposal risks.
- This will even go so far as to include stakeholder risks such as failure to meet regulatory performance requirements, etc.

The organisation shall ensure that the results of these assessments and the effects of the controls are considered and provide input into the asset management strategy and plans.

Conclusion

In conclusion, we believe that the restructuring of the electricity distribution Industry in South Africa will ultimately benefit the community and the electricity supply industry holistically.

However, it is essential for the utilities to be prepared for this restructuring by means of detailed self-examination and enhancement of current business practices. We recommend that in preparation for the establishment of REDs each utility/ municipality must establish a strong focus on enterprise asset management, by modifying organisational structures, business processes and implementation of effective asset information systems – supported by best practice frameworks such as PAS-55.

In implementing asset management practices, the following key roles must be established in order to manage an effective asset management system, as per PAS-55. The distinctive success factors for each of these roles are:

The asset owner is responsible to:

- Assess the South African regulatory requirements and influences
- Develop an investment strategy based on geographical supply demand
- Perform an asset, financial and operating performance analysis
- Establish and manage asset valuation and acquisition methods
- Perform market, economical and regulatory analysis

The asset manager is responsible to:

- Develop asset strategies, and optimisation plans
- Optimise capital allocation through long-term capital planning
- Ensure regulatory compliance and improvement actions to this effect
- Perform full life-cycle financial and operational analysis
- Contact and risk management
- Develop asset standards and specification – data specifications standards
- Macro work planning through prioritisation
- Real-time fact-based decision-making, based on accurate asset performance data
- Manage technology enablement and information analysis

The asset operator is responsible to:

- Conduct effective workforce scheduling and deployment
- Manage construction and maintenance project management
- Work practice design, deployment and monitoring
- Materials sourcing and inventory management
- Reliability and standardisation of network assets.
- Budget management and analysis
- Labour relations
- Third-party interface and outsourcing of operational activities
- Effective application of technology solutions, data collection and maintenance

It is our view that there are pockets of excellence in asset management, and differentiation in these roles embedded South Africa, and that a national wires business workgroup can consolidate the best practices knowledge and experience, and leverage this to the ailing and non-performing utility businesses.

This paper has been an attempt to make a contribution to the management of assets in the industry, and the reduction of power interruptions in the future restructured EDI.

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This paper has written with extensive reference to PAS-55, and with some reference to BS 3843-2:1992 Guide to terotechnology, and ISO 9000:2000, and NRS 089-2007 Maintenance of Electricity Networks Δ

Physical asset management as a profit driver - a "back to basics" case study approach

by Dean Griffin, Pragma Africa

In an environment where demand on asset performance, availability and above all reliability is being discussed and debated at the highest levels, focus must be placed on the systems, tools and methodologies that can be applied to maximise their effectiveness. This paper looks at how the age-old issue of lack of resources is being addressed by Pragma within a South African context.

Asset performance is directly proportional to three factors. Provision, ensuring that the correct asset is selected and installed. Operation, once provided for the asset must be operated in a manner which supports the business and ensures that the service is effective over its desired life cycle. The last factor is the care of the asset, more often referred to as the maintenance of the asset. If we are lacking in any one of the factors then our asset performance will be lower than desired. Organisations employ a large amount of effort and resources in the acquisition of assets and the subsequent operation of those assets. They invariably believe that they are also investing heavily in maintaining them as well. It is during this maintenance, or caring phase, that poor or lacking execution plays a major toll.

Fig. 1: The asset management triangle.

When you look at the reasons for this there are a number and will depend on location type of industry etc. What however seems to be consistent is the manner in which organisations approach the accusation of 'lack of maintenance'.

Lack of maintenance'

When you look in the newspapers, listen to the news and read technical reports, one of the common accusations is that there is a lack of maintenance or that the maintenance performed was inadequate. Obviously a generalisation but the truth of the matter is that despite organisations having funding and major pushes in developing refurbishment programs or maintenance tactics, all too often they fall short. The question is: why do they fall short? In the author's experience there are a number of reasons why maintenance programs fail to deliver the results which they should. Below are just some of the possible reasons:

- Incorrect maintenance tactics applied
- Lack of resources
- Lack of qualified staff
- Poor execution qualities
- Poor or inadequate supervision
- No planning or scheduling of work
- Reactive maintenance culture
- Lack of understanding of why preventative measures should be taken.

It is often the case that when the chips are down we revert to our base instincts and knowledge and all too often this is one of a "fix it when it breaks" approach. The first work to get dropped is the tactical inspections or the tactical tasks design to ensure that the desired level of performance is maintained. Focus then shifts to fixing the problems when they occur not preventing them from happening. It is a known fact that to perform a task in a reactive manner will cost more and take longer than doing the same task in a planned and scheduled manner.

In nearly all cases there are a large number of tactical maintenance activities and tasks developed and issued on a weekly basis to prevent failure but still it occurs. Either the wrong tactic is being performed or the right tactic is being performed incorrectly. The root cause of the problem for a lack of maintenance in most cases resides with lack of resource, not lack of intent to maintain.

Lack of resource

Before we talk about lack of resource we must define what resource is. Resource can be funding, labour or tools. The lack of labour resource is probably the biggest issue experienced in South Africa today. It is recognised that a lack of investment has resulted in a backlog of maintenance and funding has been made available within most municipalities, and other organisations to specifically address the backlog. However there are still large holes in organisational structures at the execution layers that lead to a lack of maintenance.

Organisations compound this deficit by then using the labour available to do non-execution activities. The key organisational element responsible for effective execution is the supervisory layer. The supervisors or foreman or team leaders are tasked with activities that prevent them from performing their primary role. They are responsible for the act of ensuring that the work is performed at the right time, to the right quality, at an effective rate and at the right cost. If a supervisor is tasked with planning work, scheduling resource, dealing with work entry and recording then the time spent supervising is low. What organisations then state is that their workforce is self-directing or autonomous. Both worthy claims but both result in a less effective labour resource.

When we don't have enough people to do the tasks at hand then it is even more important to utilise the ones we do have on the highest priority activities or the tasks that, if are not done, will hurt us most. So the question is how can we make sure that the people we have are fully utilised and effective?

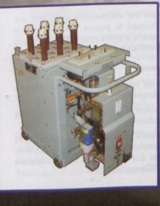

Fig. 2: Performance vs. resources.

Utilised and effective

How can organisations ensure that their depleted labour resource is fully utilised and effective in the most cost-effective manner? The answer lies in the ability to understand the requirement to perform maintenance activity albeit non-tactical urgent (breakdown), non-tactical deferred or tactical in nature. There are a few steps which must be followed to ensure that the labour force is effective.

The first is to understand the nature of the assets that are serviced by the team. If the frequency of failure is high, or the number of breakdowns is high, then there needs to be a dedicated team looking at only reactive tasks. This may be referred to as a 'firefighting' team. The size of the team will be dependent on the number of breakdowns, geographical coverage, time of year etc. The role of this team is purely to address urgent tasks. Little or no planning is performed and all activity is reactively dispatched. The utilisation of this group is relatively low. Although they have fast response times they will invariably take longer to execute the task due to the reactive nature of operation. When the tasks outstanding outnumber the team members, longer downtime or disruption occurs.

The second step to establish is a group that only works on planned and scheduled tasks. These tasks are not only tactical but they include non-tactical deferred work as well. The key is that the execution of a job only takes place when all the materials, tools and people are available to do so. A planned and scheduled job is shorter in duration and costs less than a reactive task. The upside to this is that the resulting time-saving and cost-saving can be used to perform more tasks. The efficiency of the workforce is often referred to as 'Wrench Time'.

Doc Palmer in his book *'Maintenance and Planning Handbook'* defines that typical wrench time lies between 25% and 35%. Where basic planning and scheduling takes place this can be raised from 30% to 40%. If full work planning and scheduling is performed over a rolling four week period the result can be a workforce with a wrench time of up to 60%. What does that mean to an organisation?

Assume an organisation has 30 people with a wrench time of 25 - 35% as per the industry norm. If we increase the wrench time to 55% by implementing planning and scheduling principles and tools then it equates to another 17 people. 17 extra people without increasing headcount or salary cost. So the question must be why don't we all implement planning and scheduling solutions? The answer is that most organisations do, the only issue is that the people they use to do it are the ones that should be executing the maintenance. So maybe it is a percentage of 'not enough labour resource' but it is definitely a case of a miss-directed work force.

Areas of strength

Everyone has areas where they are very strong and we often refer to this as an area of strength. True strengths are areas where time is immaterial. An engaged team is probably made up of individuals who are playing to their strengths. In a survey of 198 000 employees from 36 companies employees were asked the question of whether they were able to play to their strengths every day. Those who stated that they strongly agreed were 50% more likely to work in teams with lower employee turnover, 38% more likely to work in more productive teams, and 44% more likely to work in teams with higher customer satisfaction scores. Over time those teams that increased the number of employees who strongly agreed saw comparable increases in productivity, customer loyalty and employee retention. What this means is that to get the best from the scarce resource that currently exists we need to leverage the strengths that exist. Invariably that strength is the ability to execute maintenance tasks well. Time and effort spent reactively managing work requirements is often stated during interviews as a drain.

There is a trend in industry to outsource activities. Condition-monitoring tasks are easy examples. What we are finding more and more is the requirement for the planning and scheduling of maintenance activity and the control of the asset management information base to be outsourced. If established correctly and managed on a monthly basis with key service level agreements, a scarce execution resource is transformed into one where a healthy backlog is managed and processed to facilitate higher wrench times. Higher wrench times translate to a more effective work force which ultimately translates to higher availabilities, improved reliabilities and more cost-effective operation of the organisations asset base.

Asset care centres (ACC) are established on client sites and totally manage the asset management function providing direct access to asset information (DATA). Information can then be used to optimise systems, identify areas of opportunity and weakness and to ultimately raise the performance of the service provider. At the ACCs that Pragma manage we also drive activities such as asset identification and verification and support them in the day to day transactional workings.

Conclusions

When looking at maintenance activity it is often referred to as a cost as opposed to a profit driver. If performed effectively a reduction in maintenance cost can be achieved resulting in higher profits. The key to effective execution of maintenance is:

- Perform the right tasks at the right time correctly
- Increase maintenance labour effectiveness by providing them with good quality, well scheduled work
- Manage the execution quality through close and regular supervision.
- Release people to do what they are primarily paid to do.
- Review failures with a view to putting in place a tactical task to prevent the failure occurring again.
- Review the maintenance tasks that are performed to ensure that the task is correct, it is at the correct frequency and that the asset is performing as designed.

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New technical requirement of a distribution licence

by Thembani Bukula, NERSA

Since the early 1990s, there has been much discussion about the restructuring of the electricity distribution industry (EDI), which has been driven by the need to address a number of issues engulfing the EDI including the substantial fragmentation of the industry.

The industry is currently characterised by:

- Fragmentation of the industry which poses a huge challenge in terms of regulation;
- Serious financial and technical problems;
- Wide disparity in cost, tariff and service levels;
- Serious lack of human resource;
- Electrification backlogs;
- Scale economies and efficiency; and
- Lately, by deterioration of maintenance and infrastructure investment.

Many electricity distributors do not have the resources to maintain their networks, expansion and meet electrification and growing economic demand needs.

Restructuring into regional electricity distributors (REDs) will therefore allow the development of a more efficient industry that is better able to implement the electrification programme while not compromising the ability of the EDI to support the funding of local government or to offer subsidised electricity tariffs for poor customers. Improved service and efficiency levels will also help maintain and improve South Africa's electricity price competitiveness.

The EDI blueprint identified the following as objectives of restructuring:

- Universal access to electricity for all South Africans.
- Acceptable and sustainable levels of supply security and quality.
- Achievement of government's electrification programme.
- Sustainable electricity supply to low-income consumers, regardless of location, at affordable prices.
- Future REDs to operate on a sustained financially viable basis as independent businesses.
- Future REDs to provide secure employment to their employees, provide skills development and training consistent with a high technology, modern distribution business.
- Planned and managed transition.
- Transition to be done within the context of a comprehensive human resources strategy and an agreed social plan.

The grid code will therefore elevate some of the problems that are encountered at the distribution level. Since this is a technical document it will uniform the distribution industry and also prepare for the formation of REDs. It will also make it easier for regulation especially in the improvement of quality and reliability of supply. NERSA approved the distribution code for incorporation into the distribution licence. All distribution licensees will be required to comply with the code.

Objectives of the grid code

The distribution code will be a primary regulatory instrument that will ensure the following:

- It defines detailed conditions for access to and use of the distribution system including basic rules, procedures and requirements that govern the operation and maintenance of the distribution system.
- It will form part of the licensing conditions of the distribution network service providers.
- The restructuring of the electricity supply industry in South Africa will present significant challenges pertaining to the operation, planning and maintenance of the distribution system. The code is intended to define the technical aspects of the distribution system which the distributors and other users of the distribution system should comply with.

Electricity industry developments

NERSA is the grid code administrative authority in line with the Electricity Regulation Act (2006). The development of the RSA code (transmission and distribution) is done with the involvement of the affected in the industry through a representative panel of experts. The process for the development of the distribution code took a period of over two years, starting June 2005. It followed a rigorous process which included industry workshops under the auspices of the grid code secretariat. Participants involved in Distribution code drafting process included: NERSA, AMEU, DME, EIUG, Eskom (Gx, Tx, Dx)

The grid code (i.e. transmission code) was implemented as an extension of licensee obligations on 1 January 2005. The grid code however only catered for transmission network services. Therefore there was a need to extend the code to distribution network services. The distribution code therefore was proposed as a code that defines detailed conditions for access to and use of the distribution system including basic rules, procedures and requirements that govern the operation and maintenance of the distribution system. The distribution code will form part of the licensing conditions of all subscribers. The restructuring of the electricity supply industry in South Africa will present significant challenges pertaining to the operation, planning and maintenance of the distribution system. The distribution code is also intended to define the technical aspects of the distribution system which the distributors and other users of the distribution system should comply with.

The distribution code contains the following sections:

Code definitions

As the name suggests, this code defines terms used throughout the distribution code. This section will eventually be reconciled with the preamble code of the current transmission grid code.

Distribution network code

This section deals with requirements that will ensure open access to all subscribers (distributors, embedded generators, end-use customers, retailers, generators, any other entities with equipment connected to the distribution system.) It defines minimum technical and operational requirements for connection to the grid by generators or loads, and defines the planning standards and procedures to which the network owner needs to adhere.

Distribution tariff code

The tariff code applies to all regulated tariff structures (components and level) and negotiated pricing agreements under the jurisdiction of NERSA (governed by the relevant legislation and national policy) including international pricing agreements impacting prices for local customers. The determination of the revenue requirement is managed by a process and rules set by NERSA. NERSA shall determine a methodology for regulation of distribution revenue, currently not dealt with in this code. The tariff code applies to the following generic retail charges:

- Energy charges including recovery of losses
- Network charges, including ancillary services
- Customer services charges
- Connection charges

Start	Licensee align themselves	Submissions for exemptions	Full Implementation
	6 months	6 months	12 months

Table 1: Licensee requirements.

Distribution system operation code

This code sets out the responsibilities and roles of the participants as far as the operation of the distribution system is concerned and more specifically issues related to:

- Economic operation, reliability and security of the distribution system
- Operational authority, communication and contingency planning of the distribution system
- Management of power quality
- Operation of the distribution system under normal and abnormal conditions
- Field operation, maintenance and maintenance coordination/outage planning
- Safety of personnel and public

Distribution metering code

The objectives of this code are as follows:

- To ensure compliance with minimum requirements for tariff metering and energy trading metering installations.
- To define responsibilities for metering installations.
- To ensure that appropriate procedures are followed by the distributor of electricity (referred to as 'licensee' by NRS057 and in this code) and its metering service provider regarding the maintenance, validation, collection, processing and verification of metering data.

Distribution information exchange code

The objectives of this code are:

- To define the reciprocal obligations of participants with regard to the provision and exchange of planning, operational and maintenance information for the implementation of the distribution code.

Information exchanged between participants governed by this code shall not be confidential, unless otherwise stated.

Implementation of the distribution code

The distribution code will be implemented in two stages starting with the trial period of one year. At the end of the 12 months trial period full implementation will commence. Licensees will be informed in advanced about the inclusion of the distribution code requirements as part of their license conditions. (See Table 1)

During the first six months each licensee will be required to assess its business and align it in accordance with the requirements of the code. At the end of the first six months all licensees will be required to report their compliance status to NERSA and lodge any amendment and exemptions with the grid code secretariat. The process for lodging amendment and exemptions is covered in the governance code. Each application for exemption should be accompanied by a project plan with defined dates by which the licensee will fully comply to the code. These project plans will make it easier for tracking of progress made with regard to closing out of non-compliances.

Licensees may also apply for the code interpretation where the code requirements are unclear. Such request should be sent directly to the grid code secretariat. There will be a six months window for GCAC to review all the exemptions received after the first six months of trial period. Upon recommendation by GCAC, the exemptions will be taken to the Energy Regulator for consideration of approval. All licensees that have not submitted exemptions within the six months period, will be assumed to have complied with the code and any non-compliance thereof will be considered as a transgression of the licence condition and will be dealt with according to the Electricity Regulation Act, (Act 4 of 2006).

The rollout plan

NERSA together with the grid code secretariat will start by visiting all those municipalities of installed capacity greater than 100 MVA. The closest municipalities by geographical area to the greater than 100 MVA will also be included in this plan and the rest will be grouped per geographical area. It is intended to visit all licensees to make sure that they understand the code and the processes of applying exemptions if needs be. AMEU will be consulted to assist especially in gathering the smaller municipalities under one roof. This process is expected to run for a month and after that letters will be issued informing licensees about the inclusion of the code as part of the licence condition.

Compliance enforcement

Compliance with the distribution code will not come into effect immediately. Participants shall be given the opportunity to align their businesses to the requirements of the grid code and/or request exemption from certain provisions of the grid code.

Enforcement will therefore only commence after one year of the trial period, subject to exemptions being approved.

Compliance monitoring

NERSA has the framework in place to monitor compliance to licence conditions. Once it is included as part of the licence condition it will be enforced through this framework.

Future participation

It should be noted that the distribution code is a living document and therefore, requires continuous updating to align with the latest developments in the industry. It is therefore every participant's responsibility to ensure the code is continuously tested and updated as required. The process for the review of the code is included in the governance code. System Operator remains the secretariat of both grid and distribution codes and therefore all changes to the code, must be channelled to them. Δ

Identification of engineering work steering committee

by Enslin Naude and Ivor Evans, Engineering Council of South Africa (ECSA)

An overview of the proposed regulations for the identification of engineering work is presented.

The main purpose of work identification in South Africa is to ensure that work peculiar to the built environment is performed only by competent persons who are registered with a statutory council and who are accountable for their actions, in a manner that is consistent with government's competition policy, which protects the health and safety of the public and the environment and provides recourse in relation to aspects of professional conduct.

Regulatory backdrop to the identification of work

Section 20 of the Council for the Built Environment Act, 2000 (Act No 43 of 2000) requires the Council for the Built Environment to identify the scope of work for every category of registered persons after receipt of the recommendations of the councils for professions prepared in terms of their respective acts. Thereafter, a person who is not registered by the Engineering Council of South Africa (ECSA) may not perform any engineering work identified for any category provided for in the Engineering Profession Act, 2000 (Act No 46 of 2000).

Section 26(1) of the Engineering Profession Act, 2000 (Act No 46 of 2000) requires Engineering Council of South Africa (ECSA) to consult with recognised voluntary associations, persons, bodies and industries that may be affected by any laws regulating the built environment professions regarding the identification of the type of engineering work which may be performed by persons registered in any categories provided for in section 18 of the Engineering Profession Act, including work which may fall into the scope of any other profession regulated by the respective professions' act referred to in the Council for the Built Environment Act, 2000 (Act No 43 of 2000).

Section 26(2) of the Council of the Built Environment Act, 2000 (Act No 46 of 2000) requires the Engineering Council of South Africa to submit recommendations to the Council for the Built Environment following such consultation.

In terms of section 26.(3) of the Engineering Profession Act, 2000 (Act No 46 of 2000), candidates and persons who are not registered may not perform work identified for registered persons unless they do so under the direct supervision and control of a person registered in the appropriate professional or specified category.

Section 27 of the Engineering Profession Act, 2000 (Act No 46 of 2000), empowers the Engineering Council of South Africa to draw up a code of conduct for registered persons and to draw up codes-of-practice.

Thinking behind the identification of engineering work

The proposals for the identification of engineering work for persons registered in terms of the Engineering Profession Act are based on the following premises:

Engineering work identified for the professional categories of registration should be generic in nature. No attempt should be made to establish boundaries between disciplines and sub-disciplines within engineering work. The approach should rather be to establish the boundary between work identified for engineering professionals and those who are not. Reliance should be placed on codes of conduct and codes of practice to determine what work, within the identified work such professionals may undertake, is commensurate with their education, training, experience and contextual knowledge.

Engineering work may be identified by considering whether or not work falls within a listing of broad types of work, involves general characteristics in its execution, requires certain functions to be performed and requires minimum competencies for its execution. Engineering work is work where an affirmative answer is obtained in all of the aforementioned descriptors.

Artisans such as workers skilled in a trade, mechanics, operators and craftsmen and managers of very small and micro enterprises involved in construction works and mining activities are exempt from the need to be registered.

Persons registered within a particular category of professional registration may perform work within a range of characteristics identified for each category of registration. They may perform work within the range of another category should they deem themselves competent to do so by virtue of their education, training, experience and contextual knowledge.

1	2	3	4
Characteristics	**Types of work**	**Functions**	**Competencies**
Involves one or more of the following: Investigation and solving of problems and design solutions Application of knowledge and engineering technology, based on mathematics, basic sciences and engineering sciences, information technology as well as specialist and contextual knowledge Management of engineering works; the addressing of the impacts of engineering work The exercising of judgment and the taking of responsibility for engineering work.	*Falls within the scope of the following:* Transportation systems Civil works Structural works Mechanical systems Works for the harnessing of energy Electrical power systems Electronic systems Process systems Mining operations or activities Treatment of any substances Building services Lightning protection measures Overseeing ECSA accredited programmes at the exit level. Mentoring of candidate engineering practitioners.	*Requires in its performance any of the following:* Design Planning Investigating, advising, costing, reporting and auditing Improvement or optimisation Management, procurement and maintenance Implementation Application of the results of research and development Management of risk Communication of the impacts and outcomes Education, training and mentoring of engineering personnel	*Requires in its performance minimum competencies relating to the:* Definition, investigation and analysis of engineering problems Design or development of solutions to engineering problems Conduct of engineering activities in an ethical manner

Extract from Table 1: What constitutes engineering work .

There will always be overlaps between the different professions. Instead of trying to resolve the boundaries between professions, persons who are professionally registered with statutory councils other than the Engineering Council of South Africa should be allowed to perform any work which falls within the overlaps provided that their education, training, experience and contextual knowledge have rendered them competent to perform such work. However, where such persons regularly and consistently perform engineering work and take responsibility for such work, such persons must become registered with Engineering Council of South Africa.

The specified category provided for by section 18.(1)(c) of the Engineering Profession Act, 2000 (Act No 46 of 2000), may be used to allow persons who are not able to register in the professional categories to perform aspects of engineering work identified for registered persons. In exceptional cases, it may be used to address discipline-specific or specialist areas of engineering work performed by those registered in the professional categories. This, however, introduces dual registration and necessitates that the work performed by persons be separately identified in the Regulations.

Foreign engineers performing identified engineering work without supervision in South Africa and who take responsibility for such work, must become registered with the Engineering Council of South Africa.

Codes of practice issued by the Engineering Council of South Africa in terms of Section 27 of the Engineering Profession Act, 2000 (Act No 46 of 2000) may be used to set standards of acceptable professional practice, to provide clarity and substance to a range of issues relating to a discipline's specific work or work within specific areas and to clarify the overlaps between categories of registered persons.

It is implied in the regulations that the time period for becoming registered is reasonable and is the same for all practice areas so that no person is prejudiced by the registration process.

ECSA's identification of engineering work project

ECSA established an identification of engineering work steering committee to develop proposals for the identification of engineering work. This committee has proposed regulations for the identification of engineering work for promulgation in terms of the Council for the Built Environment Act, 2000 (Act No 43 of 2000). Engineering Council of South Africa has forwarded these proposed regulations together with an explanatory memorandum as its recommendations to the Council for the Built Environment .

What constitutes engineering work?

Engineering work is work which, in terms of the proposed regulations and with respect to Table 1, involves in its execution one or more identified characteristics (column 1), falls within the scope of listed types of work (column 2), requires for its performance any of a number of identified functions (column 3) and minimum levels of competencies (column 4). Work which falls within the identified types of work and does not in its execution have at least one of the identified characteristics, require any of the identified functions or require the stated competencies does not constitute engineering work.

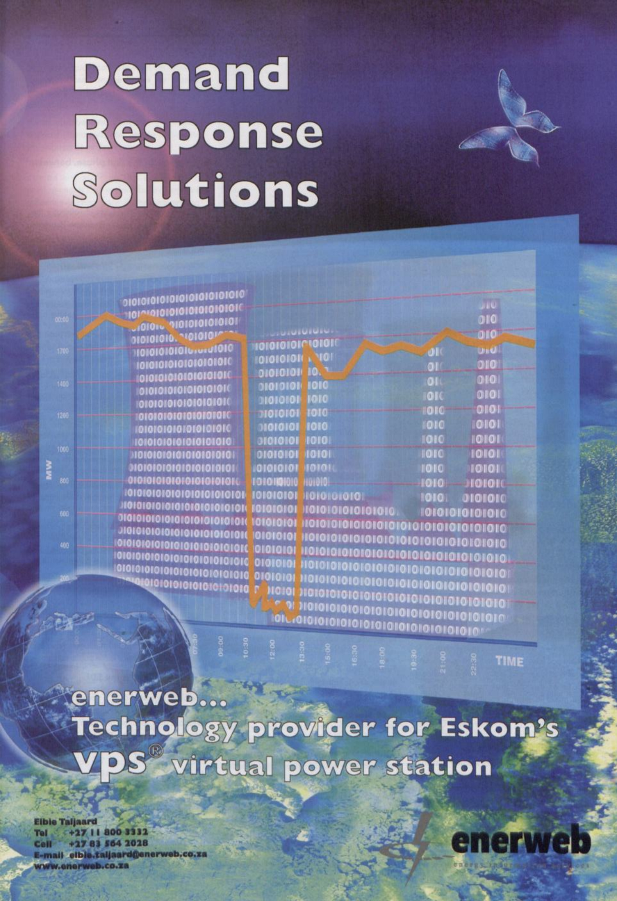
Notes

The full text of what constitutes identified engineering work, can be accessed on the ECSA website www.ecsa.co.za.

Other relevant identification of engineering work-related supportive documents are also available on the Engineering Council of South Africa website.

What happens after the minister promulgates the IDoEW regulations?

No persons shall, after the transitional period set in the regulations by the minister, be permitted to perform and take responsibility for such identified engineering work in South Africa, unless they are registered in the appropriate category with the Engineering Council of South Africa or perform such work under the direction, control and supervision of a registered person. Persons who are professionally registered with other statutory bodies may in the course of practising their profession, perform and take responsibility for such identified engineering work provided that their education, training, experience and contextual knowledge have specifically rendered them competent to perform such work. Δ


Demand Response Solutions
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Building capacity for the unfolding REDS in the EDI

by Naudé van Rensburg, Eskom

In terms of the expected economic growth, government has set targets divided in two phases. In the first phase, between 2005 and 2009, an average annual growth rate of 4,5% or higher is targetted.

During the second phase, between 2010 and 2014, an average annual growth rate of at least 6% of gross domestic procuct (GDP) is targetted. In addition to these growth rates, there is a need to ensure that the benefits of growth are shared to alleviate unemployment and poverty in South Africa. A reduction in unemployment to below 15% and a reduction in the poverty rate to one sixth of households by 2014 are targetted.

A task team led by the deputy president, and comprising of different ministries, including the Department of Public Enterprises (DPE), has been constituted to develop a strategy to ensure the achievement of the ASGISA objectives.

State-owned enterprises' (including Eskom and local government) contributions to ASGISA are integrated into the task team deliverables.

The planned regional electricity distributors (REDS) within EDI, by virtue of its core business of supplying electricity and operations of the networks, capital expansion programme and developmental mandate, is ideally positioned to make a significant contribution to ASGISA. Various national research, investigations, and debates as to whether the country has the skills capacity required by the construction and engineering environment to meet in the demand for creation and maintaining the infrastructure have been done.

Despite the growth in the electrification drive in Eskom and local government, the construction industry at large is emerging from a significant phase of decline that has seen limited investment in human capital development, resulting in the loss of available capacity. Eskom and local government's Capital expansion drive in electrifying 3,5-million households by 2012, the Eskom expansion programme in building more power stations, and government's announcement of the large government infrastructure programme in 2005, such as the Gautrain Rapid Rail link, the development of the infrastructure for the 2010 FIFA Soccer World Cup, plus the growth globally, highlighted the skills shortages. It also necessitated the investigations to ensure that the country will be able to deliver the human capital capability to deliver for infrastructure development projects and the operating and maintaining of such infrastructures.

This report has been developed using information from the many researches that have been done. Refer to acknowledgements.

The Joint Initiative on Priority Skills Acquisition (JIPSA) has identified a number of priority skills such as artisans, engineers in all categories in engineering. JIPSA's target is to facilitate the training of up to 50 000 artisans by 2010.

Current status

Commercialisation of state-owned entities (SOS) training facilities from 1987/88 onwards coupled with the rationalisation and consolidation, which took place within government post-1994, resulted in a severe decline of training capacity in the country.

SOE and industry training facilities decreased dramatically by closing rather than building capacity. The outsourcing of training across SOE as well as industry has further contributed towards this.

One of the factors hampering expanding capacity across the board, aside from the costs of upgrading training equipment, is the severe shortage of qualified technical instructors. The shortage of qualified and registered workplace mentors, coaches and assessors has been identified as an important contributing factor to ensure that critical workplace training occurs.

Further overwhelming conclusions of the investigations highlighted a number of serious challenges.

"...as many as 90% of South Africa's consulting engineering firms are trying to employ skilled engineers, technologists and technicians but finding it hard to identify prospective candidates." The Civil Engineering Contractor Bulletin, 16 October 2006.

There is a concern that the current boom promise may fade due to the lack of skills. Eskom's chief economist, Mandla Maleka says government has to provide an environment for a bigger pool of skills "even if it is regulatory", to plug the gap. The skills shortage is considered so serious it could sabotage the ASGISA initiative. Deputy President, Phumzile Mlambo Ngcuka, who is driving the initiative, has alluded to this:

"Government's R372bn infrastructure investment between now and 2009 is expected to stretch the country's skills pool to its limit." Business Day 13 June 2006.This excludes the Eskom capital expansion programme.

The current growth rate puts enormous pressure on the depleted skills in the country and will need substantive interventions because:

- The current growth in infrastructure investment has come on the back of lows in the industry that have not been experienced in decades.
- Labour practices of the past decade have resulted in fundamental structural changes favouring labour brokering, resulting in declining investments in skills development.
- There have been fundamental changes, and breakdowns, in the skills supply pipeline.

To enable the industry to reach the planned growth rate targets over the next five years it is imperative that the following demand for skills is achieved:

- Management, supervisory and engineering capacity to be developed
- Artisans are developed to provide the core, critical and scarce skills

Furthermore, of great concern is that almost 40% of the senior officials and managers have five years or less experience in the public sector.

Capacity needs in the EDI

The audit indicated a 41% vacancy rate for the artisan levels withing local government. Skills are also required at Eskom for infrastructure projects

Pipeline output

Analysis done in the skills pipeline from schools, further education (FET), and higher education (HET) shows increasing numbers of students entering the training institutions. The nett output of the pipeline is negatively affected by the success rate of throughput, natural attrition, changes in work processes and the lack of experiential (workplace) training for qualification to meet the required demand. Based on the above the biggest gap exists in the critical and scarce skills categories.

It has also become clear that the human capacity (instructors, coaches) to deliver the training has been depleted.

The lead time to provide adequately competent staff in the engineering environment is long and will have a negative influence leaving gaps in the engineering environment if immediate actions are not instituted. The time to deliver a professional registered engineer is eight years (without experience) for technicians, and artisans four to five years. The high attrition rate in the critical and scarce categories plus the lead time to deliver these competencies places more challenges on meeting the requirements.

The acceleration of the study period for a qualification poses other negative results on the level of competencies. The learning part can be accelerated and shortened but the lack of practical workplace training negatively affects the level of competence which leads to accidents, fatalities, and sub-standard work. Experience and workplace training cannot be accelerated.

Estimated Engineering and artisan requirements in local government				
Artisan Type	Total extrapolated			
	Filled	Vacant	Vac as % total	Totals
Boilermaker/Welder	144	96	40%	240
Electricians	2915	1608	36%	4523
Fitters	168	36	18%	204
Instrument Mech	36	24	40%	60
Machinery operators	24	36	60%	60
Millwright	36	60	63%	96
Sen Eng asst.	84	84	50%	168
Traffic signals	36	12	25%	48
Traffic signal asst	36	12	25%	48
EDI Total	**3479**	**1968**	**36%**	**5447**

Table 1: Estimated EDI artisan requirement in local government.

Skills required for period (2006- 2012)	Eskom Dx	Eskom build prog	Total
Coded welders		300	300
Draughtsman		65	65
Electrical fitter		20	20
Electricians	4300	300	4600
Engineering technician (electrical)		300	320
Engineering technician civils		160	180
Engineers-mechanical, electrical, instrumentation		400	400
Fitter		600	611
Instrument technicians		200	200
Millwright			33
Officers		400	400
Project managers	40	200	240
Sheetmetal workers		30	34
Supervicer		200	201
Welder	200	30	253
Finance managers	10	400	410
Safety advisors	10	300	310
Technicians	50		50

Table 2: Estimated EDI artisan requirement in Eskom.

Schools pipeline

South Africa's school system produces 10 000 students with matric exemption with results of between an A and C symbol in higher grade mathematics and science annually:

- 1995: 1 666 980 pupils started in grade 1
- 2001: 932 161 reached grade 7, 55% of those started in grade 1. 45% drop-out.
- 2006: 528 525 pupils wrote grade 12, 32% of the learners that started in grade 1 in 1995, a 68% drop-out
- 351 503 passed grade 12 or 21% of those that started in grade 1, a 79% drop-out
- 85 830 obtained matric exemption, or 5% of those started in grade 1
- 10 000 obtained matric exemption with between A and C symbols in higher grade mathematics and science, or 0, 6%.
- The drop out rate of the students between Grade 10 to grade 12 is 50%

The minister of education, Naledi Pandor announced on 17 September 2009 the implementation of a General Education Certificate at grade 10 level. This will support the proposed development of a linesman type qualification and career path.

In an international mathematics and science study South Africa was ranked last.

50 countries participated where the grade 8 pupils were assessed. The maximum points that can be achieved were 800 points. Four levels of achievement were specified:

- Advanced international benchmark
  = 625 points and above
- High international benchmark
  = between 550 and 625 points
- Intermediate international benchmark
  = between 475 and 550 points
- Low international benchmark
  = between 400 and 475 points

The top achievers were Singapore (605 points), South Korea (589 points), Hong Kong (586 points), Taiwan (585 points) and Japan (570 points)

South Africa ended the lowest scoring 264 points on mathematics and 244 on science. 10% and 13% of SA grade 8 learners participated, respectively scored higher than 400 points.

"Inadequate mathematics and science education is probably the single biggest obstacle to African advancement in the country. It impacts severely on the development of high-level skills in the workforce and thus limits economic growth". (From Laggard to World Class Reforming Maths and Science Education in SA schools. Centre for Development and Enterprise, 2004)

The fact of the apparent low standard has a direct correlation with the success rate to produce artisans, technicians, technologists and engineers. However as indicated previously this creates the opportunity for industry to use the numbers that are not academically strong enough to be trained as artisans, starting from a grade 10 level.

Tertiary institutions

Fig. 1 indicates the output of all the engineering disciplines in SA for which all industries have to compete.

The output of graduates is increasing year on year. Despite of the growth, the average time to attain a BSc Eng degree has increased from 48 months to the current 56 months)

Of all graduates available in 2004, 39% qualified with a national diploma, 31% with a first degree, and 6% with BTech. The figures indicate the total number and not only engineering (see Fig. 2).

Legislation places heavy demands on specific population groups that are not readily available. In 2004 an average of 18,5% of graduates available from universities and universities of technology across all engineering disciplines was African (see Fig. 3).

Employment equity legislation prescribes strict targets of employment of historically disadvantaged South Africans even though the following is the reality regarding availability.

In 2004:

- Only 15% of available graduates in industrial and mechanical engineering disciplines was African
- 17% of available graduates in metallurgical engineering was African
- 20% of available graduates in mining engineering was African
- 28% of available graduates in chemical engineering was African
- 19% of available graduates in electrical and electronic engineering was African

Attrition rate of skilled technical competencies

Typical attrition rate in Eskom

The attrition rate amongst black males is much higher than the other categories which possibly is an indication of the lucrative opportunities in the external markets.

Attrition of staff to foreign countries

Major lossess occurs due to self-declared South African emigrants. The major countries are United Kingdom, Australia and the rest of Africa, whereas the most popular source of countries of immigrants are Nigeria and the rest of Africa (see Fig. 5).

SA has suffered a net loss of skills due to migration. Stats for 2003 (see Fig. 6) are:

- 60 industrial engineers
- 6 chemical engineers
- 3 electrical engineers
- 3 mechanical engineers

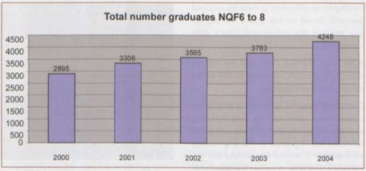

Fig. 1: The graduation trends and availability national learners records database form SAQA.

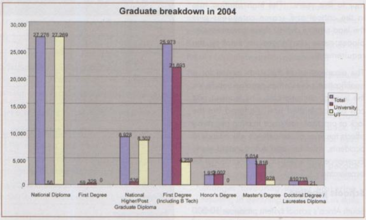

Fig. 2: Graduate breakdown in 2005.

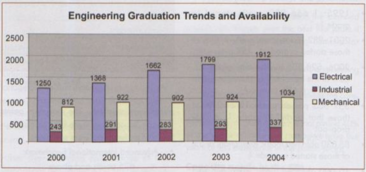

Fig. 3:. Engineering graduation trends and availability.

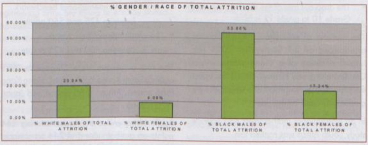

Fig. 4: Typical attrition rate in Eskom.

Distribution networks just got better

N-Series three phase automatic recloser with advanced controller

- Up to 38kV system voltage
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- 1 metallurgical engineer
- 29 mining engineers
- 356 artisans
- 25 production foreman/supervisors

Resource capacity in the EDI to deliver training

Audits were done in the SOEs with specific focus on the competencies that will be required in the EDI. The report is not focused on the training of "generic" industry electricians because the resources - both instructors and facilities - in this area are much more available. The competencies of electricians required in the Distribution business are more focused on build, maintain and repair of overhead lines, and substations.

The critical shortage of technical instructors is evident, and the age distribution of the current instructors clearly indicates an ageing workforce, and urgent attention is required to this area to build the necessary capacity.

The survey revealed that the average learner/instructor ratio varies 10:1 to 15:1. However, it emerged that there is a shortage of qualified technical instructors across all categories. This could impact negatively on the ability of training institutions to maintain and increase their existing training capacity. A similar problem exists around the shortage of workplace assessors and mentors, which should form the basis of further research.

Preliminary estimates reveal that the current shortage of instructors across government (including local) and SOEs is in excess of 120.

It is estimated that the shortage in the SOEs, e.g. Eskom and local government, is in excess of 55.

Planning and design	• Network master planners • Design and project engineers • Surveyors • Design draughts persons
Primary plant	• Artisan • Linesmen • Switchgear specialists • Cable specialists • Live work
Training	• Technical instructors • Line coached • Line mentors • Live work instructors
Capital Expansion	• Project managers • Project co-ordinators • Clerk of works
Secondary Plant	• Protection planning, design and co-ordination • Protection and metering field execution • SCADA system support • SCADA field execution
Quality of supply and reliability enhancement	• Plant engineers • QOS engineers
Network Management	• Network controllers • Network outage schedulers

Table 3: Slils categories.

The reasons for the current shortage of instructors are multi-faceted and require further research. However, during the course of this study, the following emerged as some of the contributing factors:

- A consequence of allowing training capacity to deplete (as occurred to varying degrees across SOEs and government) has been the failure to retain staff, especially in the case of technical instructors. Training centres, wanting to increase capacity, are now finding it extremely difficult to attract instructors in the distribution electrical field, with the necessary skills and competencies and ability, to train learners in this field. A suitably qualified instructor in the distribution environment is regarded as a critical and scarce skill and is not readily available.
- People are rather hesitant to become instructors, as they believe that educators are not valued in society. This raises issues around status and remuneration of such professions within the public sector and beyond.
- A number of institutions indicated that their instructors had left for more lucrative jobs in the private sector; had become consultants or had left the profession. One or two institutions indicated that there was little incentive for instructors to remain in service because of the lack of career-pathing and upward mobility.
- Most employers have found that there is not a high level of willingness amongst their personnel to become instructors. This is especially so in relation to experienced artisans. Many of them do not have the aptitude for training while others believe that there is not a sufficient incentive to move into training. There is a view that an instructor is considered to be a more 'low level employee' as he is no longer on the production line.

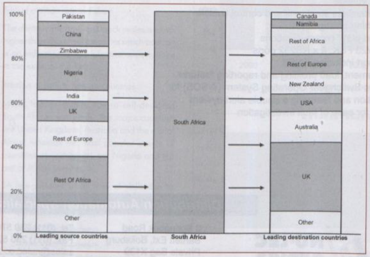

Fig 5: Source and destination countries.

- An added factor is that the job of an instructor is not an easy one – hence the need to consider some form of built-in incentives to encourage suitable candidates to consider training as a career option. Eskom is currently exploring various ways in which to incentivise senior artisans to become instructors, not necessarily on a permanent but rotation basis.

Figs. 7 to 10 indicate the numbers of instructors in the EDI (Eskom and local government) that can deliver in the distribution requirements. The generic category refers to the training of the "generic" electricians, where the Dx category refers to distribution specific competencies. The numbers of the different categories can be a double count, where the same instructor may be multi-skilled to deliver in more than one category.

The age distribution graph indicates an ageing workforce. The majority of instructors in the 41 - 50 age groups tend to be more towards the upper level of the age group.

Facilities capacity in the EDI to deliver training

Site visits to Eskom and local government electrical training centres revealed that there are well equipped centres including classrooms, but some are in the need of upgrading.

There is a real need to improve and equip simulators to enhance the training of distribution-related training such as: line construction, inspection, maintenance and repairs; and substation construction and maintenance.

The main factors in the industry that are hampering expanding of capacity are:

- Funding of upgrading equipment and facilities
- Severe shortage of technical instructors
- Shortage of workplace mentors and coaches

Provincial and local government revealed the following:

- The main training capacity is within the metros
- Municipal training centres used to exist in 18 municipalities around the country but were closed down or reduced to a minimum
- Smaller municipalities are hesitant to develop artisans due to the lack of instructors, and workplace assessors
- Finding accredited providers and funding
- Some municipalities possibly diverting training budgets to other activities

Although the graph indicates that there is a capacity to train 554 artisans, it actually refers to the "generic" electricians. The current actual capacity in the EDI to train distribution electricians is less than 250.

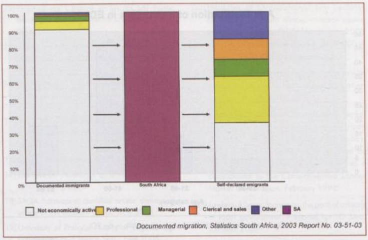

Fig. 6: Documented migration from South Africa.

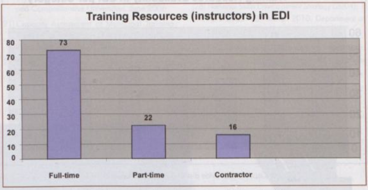

Fig. 7: Instructors with distribution electrical skills in the EDI.

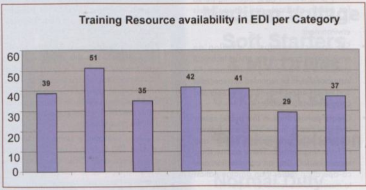

Fig. 8: Instructors with distribution electrical skills per category in the EDI.

Recommendations

- Starting at the pipeline, industry will need to get involved at school level to create more interest amongst learners in maths and science.
- Completion of a lower entry level into the labour market with specific focus on "qualifications" such as linesmen etc. This can capture the drop out rate between grade 10 and 12, which is currently unemployed, and so encourage the learners that are dropping out to become artisans.
- Identification of possible skills programmes that will give current employees without the required academic qualifications

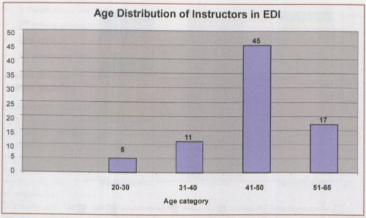

Fig 9: Instructors with distribution electrical skills in the EDI.

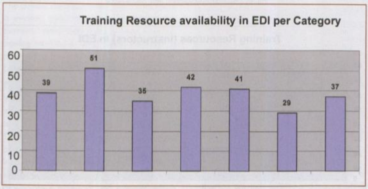

Fig. 10: Capacity to provide distribution electrical skills in the EDI.

credits and mobility towards qualifications. Skills programmes have been registered for artisan assistant, and artisan levels in both construction and distribution environment.

- Set up focus groups to develop an environment conducive to attract technical instructors to the training environment. An instructor should be regarded as a specialist and subject expert that will transfer skills and competencies to learners.
- Create partnerships in the public sector and specifically in the SOE, e.g. Eskom, Transnet, local government, SANDF and FET training centres. These partnerships should be focusing on optimisation and co-operation rather than amalgamation to maximise the resource capacity.
- Creating training hubs throughout the country where the assessors, instructors and assessment centres can be accessible to the industry at large.
- Create contractor training academies where contractors and suppliers in the SME and BWO environments can be trained. Seek support and establishment of such academies as an institute of sectoral and occupational excellence (ISOE). Every SETA must identify and support at least five ISOEs within the public sector. Negotiations have already started with the EWSETA to possibly recognise and support the contractor academy as an ISOE.
- Establish public and private sector partnerships within the private sector to train artisans, whether it is company-linked training facilities, private training providers or the former regional training centres. In the event where insufficient capacity exists within the EDI, linkages could be explored with the private sector.
- Research indicated a potential shortage of over 120 technical instructors across government and SOEs. Various options could be explored to rectify the situation:
- In the short term, re-employing former artisans who took packages during the restructuring of SOEs and local authorities to be trained up as Instructors, mentors, coaches and assessors.
- Investigate and develop strategies to attract and train more experienced existing artisans in the organisation to become instructors. Identify and use best practices to draw such resources.
- If there is a well-defined strategy to building the capacity in the industry, consideration can be given to the importing of instructors for a short period to deal with the current backlog. Such an approach would require very specific conditions around a skills transfer arrangement.
- To ensure that experiential learners will get the required workplace training and exposure, it is proposed that the same strategy is followed as in the construction environment with the establishment of an employment skills development agency (ESDA) to manage the legal and administrative hurdles of placing learners with multiple workplaces to ensure access to appropriate training as required. The flexible ESDA model, by acting as a lead employer and co-ordinating workplace experience, can ensure that individuals are moved across projects and are able to have continuity in learning, and in this way develop the required experience and competence.
- Creation of "Centres of Excellence", where research on applied technology can be done.
- Support the ASGISA project by providing job opportunities to learners within the industry.
- Develop strategies to build capacity in areas that are currently critical to ensure a successful creation and sustaining of the REDS.

Conclusion

Studies by different groups revealed:

"..there is a lack of physical infrastructure but a bigger contributing factor is the low level, and uneven spread of training intellectual capacity (instructors), updated equipment and funding. In view of this, it is critical that mechanisms be explored to firstly, consolidate resources which exist (instead of seeking to create new ones) in a way that maximises existing capacity and thereafter, engagement around alliances and partnerships. One of the biggest impediments however, is resources to drive such processes. Recapacitating the state: locating government's training capacity". Renee Grawitzky

"Challenges relating to the skills pipeline cut across the education, training and workplace arenas. The problem is not merely to equip new entrants with skills, but to ensure that they gain the appropriate workplace experience to consolidate their craftsmanship, supervisory and professional capabilities. A further challenge is the predominance of an ageing skilled population which needs to be replaced without compromising quality and performance". CIDB Skills for infrastructure delivery in South Africa "The challenge of restoring the skills pipeline" discussion document

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Electrical accident safety briefing

An existing substation was to be decommissioned and replaced by a new, upgraded substation at the same site. A fatal contact incident occurred at the final stage of the decommissioning process. The incident provoked a rethink of the definition of "decommissioned."

"Decommissioned" means different things to different people, and to different engineering departments.

A definition of decommission should be:

The formal procedure for the removal of apparatus or systems from the existing system for an extended period exceeding three months.

Incident recall

A new Eskom substation and customer substation had been built adjacent to the old existing substations.

A consultant was appointed as project manager to build the new substation. A member from the plant department was appointed to co-ordinate the "decommissioning" of the old substation. A list of usable equipment was identified and specified to be salvaged by the two technical specialist groups. The two team leaders met on site and agreed on who would salvage which equipment.

A major outage had been arranged for 25 June 2006 to commission the last transformer of the new substation and to disconnect the bypass 88 kV line from the old substation.

The project leader for the decommissioning work communicated via e-mail (three times) on the salvage work to be done, stating that the old substation was "decommissioned". The project manager failed to arrange for a Live-Line team to disconnect the temporary bypass on 25 June 2006.

The five-man technical specialist team arrived on site on 12 July 2006 at 11h40. The team gained access to the substation by removing the unlocked sliding gate with a crane.

The team did a thorough inspection and completed and signed a risk assessment. The team first removed a breaker from the secondary side of a transformer. The deceased ascended a stepladder to loosen a 88 kV isolator, when a flash-over occurred, injuring him severely. He received first aid, was stabilised by paramedics and transferred to hospital. He was transferred to Milpark Hospital in Johannesburg later that day, where he died as a result of these injuries on 25 August 2006.

Facts obtained from the incident investigation

The immediate causes of the incident were:

- Failure to adhere to ORHVS:
- Conductors not tested to be dead.
- No visible working (induction) earths applied.
- Network control was not contacted.
- Failure to identify that the temporary bypass was still connected to the incoming feeder
- Failure to barricade and to put warning signs at the 88 kV No2 Infeed - abnormal isolator

The underlying incidents causes were:

- Inadequate communication, co-ordination, integration and follow-up between the construction and decommissioning project leaders.
- Inadequate communication and co-ordination the operating staff, technical specialists and the decommissioning project leaders.
- Critical information had not been verified.
- Huge workload of the local operating staff.
- Inadequate exposure to decommissioning work by the technical specialist staff.
- Difference in opinion/understanding as to the meaning of "decommissioned."

Contributing factors

- The jumpers from the bypass line were not visible from the substation.
- Three of the five member team have valid authorisation as responsible persons in terms of ORHVS – duplication of authority.
- The quality of the flame-proof clothing is questionable.
- The first aid kits are inadequately equipped with burnshields.
- All statutory reports of the incident had been made in time.
- A small notice attached to the old substation gate warned that the local supervisor/engineer must be contacted for access to the substation was ignored.

Recommendations

- Reinforce access control to all substations (decommissioned or not).
- Reenforce barricading and displaying of warning signs for all abnormal plant.
- Reenforce the adherence to working between visible working earths at all times (decommissioned or not).
- All equipment shall be considered live until isolated, safely tested and earthed.
- No team member will come in close proximity to any equipment until the responsible team leader has physically demonstrated that the equipment is dead.
- A single project leader shall be formally appointed for any project where multiple departments are involved. The integration, co-ordination and communication process shall be documented and adhered to at all times.
- Produce a uniform definition of "decommissioned" and process for the decommissioning of plant. Δ

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Representative	Brian Madeley	P O Box 13442, Vorna Valley, 1686	quality@iso-tech.co.za	(011) 466-3701	(011) 466-3699
Jos Engineering	Lawrence Chetty	P O Box 17711, Norkem Park, 1631	vmc@absamail.co.za	(011) 393-4674	(011) 393-1583
KBK Power Solutions	Fred Peters	P O Box 133, Cato Ridge, 3680	fred@kbkps.co.za	(031) 782-1329	(031) 782-1329
Kelman	Karl Smith	Suite 038, P Bag x1037, Heritage Park, Germiston Rd	k.smith@kelman-africa.com	(011) 626-2328	(011) 626-1199
KoCos Measurement & Control	Hein Erwin	P O Box 3585, Durbanville, 7551	herwin@kocos.co.za	(021) 982-0016	(021) 982-0230

AMEU Affiliate Members

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Landis + Gyr	Braam de Swardt	P O Box 281, Isando, 1600	braam.deswardt@za.landisgyr.com	(021) 532-0733	(011) 921-7977
Landis + Gyr	Iqbal Ganie	P O Box 35064, Northway, 4065	iqbal.ganie@za.landisgyr.com	(031) 710-4104	(086) 651-4911
Landis + Gyr	Dawie van Niekerk	P O Box 281, Isando, 1600	dawie.vanniekerk@za.landisgyr.com	(011) 921-7900	(011) 921-7977
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LH Marthinusen	Tony John	P O Box 27440, Benrose, 2011	altinods@lhm.co.za	(011) 615-6722	(011) 616-6808
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Lyon & Vennote	M Lyon	P O Box 3925, Vanderbijlpark, 1900	mlyon@lyon.co.za	(016) 981-6270	(016) 933-0277
Machine Assessment Reliability Tech	Mario Kuisis	P O Box 3227, Randburg, 2125	mario@martec.co.za	(011) 886-5378	(011) 787-0160
Ma'emsa	Francois Kriel	P O Box 2212, Florida Hills, 1716	admin@maemsa.co.za	(011) 674-2772	(011) 672-1786
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Manelec Services	JF Steyn	P O Box 2910, Port Alfred, 6170	manelec@border.co.za	(046) 624-2506	(046) 624-3167
Marqott Holdings	Ray Neale	P O Box 757, Halfway House, 1685	rayjay@marqott.co.za	(012) 653-9800	(012) 653-9800
McWade Linegear 2000	Geoff Auton	P O Box 1334, Ferndale, 2160	marketing@linegear.co.za	(011) 316-2262	(011) 507-6500
Megatron Energy	Bedreich Otto	P O Box 2371, Kempton Park, 1620	otto@megatronfederal.com	(011) 976-3003	(011) 393-3858
Merz and McLellan	Bob Wallis	P O Box 345, Pinegowrie, 2123	wallisr@merz.co.za	(011) 886-6573	(011) 886-8735
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AMEU Honorary Members

1915-1936	Dr HJ van der Bijl*	ESC
	J Roberts*	Durban
	E Poole*	Past Secretary
1938	LL Horrell*	Pretoria
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	AT Rodwell*	Johannesburg
1950	Dr JH Dobson*	Johannesburg
1951	HA Eastman*	Cape Town
1955	W Bellad-Ellis*	East London
	JC Fraser*	Johannesburg
	C Kinsman*	Durban
1956	WH Miltone*	ESC
	A Morton Jaffray*	Salisbury
	Major SG Redman*	Merz & Mellan
	Clr CEK Young*	Pietermaritzburg
1957	DA Bradley*	Port Elizabeth
1958	Col GG Ewer*	Pietermaritzburg
	A Foden*	East London
	Clr Halley*	Pietermaritzburg
1960	Clr FJ Castelyn*	Bloemfontein
	Clr LP Davies*	Springs
1962	AR Sibson*	Bulawayo
1963	CG Downie*	Cape Town
	JC Downey*	Springs
	RW Kane*	Johannesburg
1965	GJ Muller*	Bloemfontein
1967	Clr JD Marais*	Johannesburg
	JR Telles	Maputo
1969	W Beesley	Estcourt
	PA Giles*	East London
	D Murray-Nobbs*	Port Elizabeth
	EL Smith*	Boksburg
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	ACT Frantz*	Cape Town
	HT Turner*	Kloof
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	RMO Simpson*	Durban
	W Rossler	Pretoria
	F Stephens*	Durban
	JF Lategan*	Stellenbosch
1973	RG Ewing	Past Secretary
1975	Clr HG Kipling*	Germiston
	C Lombard*	Germiston
	DC Plowden*	Johannesburg
	JG Wannenburg*	CI of Factories
1977	Dr RL Straszacker*	ESC
	AA Middlecote	Fish Hoek
	GC Theron*	Vanderbijlpark
	JC Waddy*	Pietermaritzburg
1979	RW Barton*	Welkom
	Clr HJ Hugo*	Roodepoort
1981	JDN van Wyk	CSIR,
	Dr RB Anderson	CSIR, Lynwood
	J Morrison*	Plettenberg Bay
1983	TC Marsh	Northmead
1983 & 1988	JK von Ahlften	Springs
1985	AA Weich*	Chief Insp.
	KG Robson	East London
	Clr RL de Lange*	East London
	E de C Pretorius	Potchefstroom
	W Barnard	Johannesburg
1987	AP Burger	Pretoria
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	DH Fraser	Durban
	PC Palser	Cape Town
1989	PJ Botes	Roodepoort
1989 & 1988	MPP Clarke	Randburg
	EG Davies	Pietermaritzburg
	JA Loubser*	Benoni
1991 & 1998	AHL Fortmann	Boksburg
1993	FLU Daniel	Cape Town
	JE Heydenrych	Middelburg
	B van der Walt	General Sec
1995	CE Adams	Port Elizabeth
	B Madeley	Iso-Tech Systems
1997	JD Algera	Rustenburg
	HR Whitehead	Durban
	F van der Velde	NER
1999	JG Malan	Kempton Park
2001	HD Beck	Buffalo City
	CE Burchell	ABB Powertech
2003	AJ Van der Merwe	Manguang
2005	PE Fowles	Pietermaritzburg
	T van Niekerk*	Edenvale
2007	D Potgieter	Polokwane
	A van der Merwe	Netgroup

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1915-1917	JH Dobson*	Johannesburg
1917-1918	J Roberts*	Durban
1919-1920	B Sankey*	Port Elizabeth
1920-1922	TWC Dodds*	Pretoria
1922-1924	GH Swingler*	Cape Town
1924-1926	Roberts*	Durban
1926-1927	B Sankey*	Johannesburg
1927-1929	JM Lambe*	East London
1929-1931	R MacCauley*	Bloemfontein
1931-1933	LL Horrel*	Pretoria
1933-1934	LF Bickell*	Port Elizabeth
1935-1936	GG Ewer*	Pietermaritzburg
1936-1937	A Rodwell*	Johannesburg
1937-1938	JH Gyles*	Durban
1938-1939	HA Eastman*	Cape Town
1940-1944	IJ Nicholas*	Umtata
1944-1945	A Rodwell*	Durban
1945-1946	JS Clinton*	Harare
	JW Phillips*	Harare
1946-1947	GJ Muller*	Bloemfontein
1947-1948	C Kinsman*	Durban
1948-1949	A Foden*	East London
1949-1950	DA Bradley*	Port Elizabeth
1950-1951	CR Hallé*	Pietermaritzburg
1951-1952	JC Downey*	Springs
1952-1953	AR Sibson*	Bulawayo
1953-1954	JC Fraser*	Johannesburg
1954-1955	GJ Muller*	Bloemfontein
1955-1956	DJ Hugo*	Pretoria
1956-1957	JE Mitchell*	Bulawayo
1957-1958	A van der Walt*	Krugersdorp
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1963-1964	JC Downey*	Springs
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1967-1969	GC Theron*	Vanderbijl Park
1969-1971	HT Turner*	Umtali
1971-1973	JK Von Ahlften	Springs
1973-1975	JC Waddy*	Pietermaritzburg
1975-1977	E de C Pretorius	Potchefstroom
1977-1979	KG Robson	East London
1979-1981	PJ Botes	Roodepoort
1981-1983	DH Fraser*	Durban
1983-1985	W Barnard	Johannesburg
1985-1987	JA Loubser*	Benoni
1987-1989	AHL Fortmann	Boksburg
1989-1991	FLU Daniel	Cape Town
1991-1993	CE Adams	Port Elizabeth
1993-1995	HR Whitehead	Durban
1995-1997	JG Malan	Kempton Park
1997-1999	HD Beck	East London
1999-2001	AJ van der Merwe	Bloemfontein
2001-2003	J Ehrich	Pretoria
2003-2004	PE Fowles	Pietermartizburg
2005-2006	D Potgieter	Polokwane
2006-2007	V Padayachee	City Power

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Bokkie Boshoff	Vanderbijlpark
Gerhard Gerber*	Zwellweger
Ian L Hobbs*	Uitenhage
Nat Kirschner	Reyrolle
Prof. Ryno Kriel	Bloemfontein
Ald Ben Steyn*	Boksburg
Theunis C Stoffberg*	Eskom
13th Technical Meeting - September 1990	
ACT Frantz*	Cape Town
JAD Foubister	SABS
F Prins	Public Work
WP Rattey*	Strand
Prof. K Van Alphen	SABS
Jan Venter	Cape Town
14th Technical Meeting - August 1992	
William Lashley	GEC
Emil de Villiers	Rustenburg
15th Technical Meeting - August 1994	
Ald Frikkie Kotze*	Port Elizabeth
J van Soelen Lochner	Pietersburg
William Tindle	Reyrolle
16th Technical Meeting - October 1996	
KJ Murphy	Somerset West
PJ Muller	African Cables
AJ van den Berg	Krugersdorp
17th Technical Meeting - September 1998	
Clive Burchell	ABB Powertech

* Deceased

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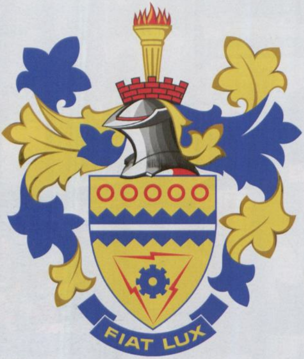

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