LEADING THE ELECTRICITY DISTRIBUTION INDUSTRY

AMEU

66th AMEU Convention

8 to 11 October 2017

"Electricity landscape of the future"

Special AMEU Convention Proceedings edition

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The independent power and energy journal of South Africa

AMEU Proceedings

2017

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Index

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Our new **COMPANO 100** is a unique, battery operated testing tool for all types of basic testing tasks in electrical energy systems. It's lighter and easier to use than all of the comparable test sets on the market today.

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www.omicronenergy.com/newCOMPANO10

Energy storage management made easy

Information from DV Power

Improper functioning of battery systems installed in utilities, power plants, telecommunication systems, industrial applications, and so on, can cause severe failures of the supported equipment and loss of critical information. At substations, for example, a battery which is unable to provide a sufficient supply of power to circuits could lead to catastrophic consequences.

Batteries are designed and sized to provide a certain amount of current for a given amount of time. The only method to determine whether the battery will support the load for the needed duration is a capacity test. That is why among all the tests, the discharge test, (also known as a load test or a capacity test) is the only test that can accurately measure the true remaining capacity of a battery system and consequently gain an insight in the operational condition of a battery. A discharge test needs to be performed with automated test equipment that can log data of all individual cells during the discharge process and locate the weak cells and faulty inter-cell connections.

For this reason, battery systems ought to be tested in order to verify their actual state of charge (SOC) or state of health (SOH) and to prevent unwanted scenarios which could result in significant budget loss as well as endanger human lives.

DV Power, with headquarters in Stockholm, Sweden, was founded in 2000 by a group of engineers with extensive experience in power electronics technology. The company's main focus is to manufacture high quality test and measurement equipment for the electric power industry.

Key to the company's success is extensive research, development and undertaking speedy analysis of new commercial applications which enables it to offer products as soon as the cutting edge solution becomes commercially viable.

DV Power has a unique philosophy: to make instruments that are meant to last – at a reasonable price. Often, inferior products are purchased, in our-throw away consumer mentality of today, which does not incentivise longevity. DV Power provides a three-year warranty on all products. That is a guarantee to its customers that they will receive the highest quality instrumentation available and it changes the focus from cheaper manufacturing options – to quality products that last. Part of this philosophy is that software and firmware updates are included in the deal. Therefore, when new features are added your instruments won't be left behind.

Typical customers include electric utilities, servicing and manufacturing companies, as well as transportation and mining industries. A list of customers in South Africa includes: Eskom, Rotek, Powertech Transformers, Wegezi, Actom Distribution & Large Transformers, Maxi Concepts, Reliable Transformers, Delba Motors, Transfix Transformers, HyPower – to name but a few.

With a rising presence in the world market and representatives and distributors worldwide, the company's products are in use in more than 80 countries.

DV Power's battery testing equipment is able to perform the following battery measurements using BLU, BLX, BVS or BVR devices:

- Voltage string and/or cell
- Inter-cell connection voltage
- Capacity
- Internal resistance measurements
- Cell/ambient temperature measurement
- Short circuit current estimation

Density of electrolyte can also be measured and logged using a third-party device.

The BLU series of devices are a lightweight solution for test engineers, developed to meet customers' wide ranging test procedures.

Using a BLU device, the capacity test is performed in an accurate, user-friendly way in accordance to the following standards: IEEE 450-2010/1188-2005/1106-2015, IEC 60896-11/22.

Discharging can be performed at constant current, constant power, constant resistance or in accordance with a pre-selected load profile. The discharge test can even be conducted when a battery remains connected to the load – by measuring and taking into account the load current during the process.

The BLU series of devices provides a discharge current of up to 340 A and up to 650 V.

When a required discharge current or power exceeds the capacity of a single BLU device, up to ten BLU devices can be connected in parallel. Alternatively, external load units (BXL series) can also be used to increase discharging capacity. Combined with battery voltage supervisor, BVS, and battery voltage recorders BVR, BLU series devices are powerful tools which enable performing detailed evaluation of batteries.

In South Africa, DV Power products are distributed and supported by Action Instruments, with product repairs and calibration undertaken locally by a SANAS accredited laboratory with factory trained personnel. The company's experienced customer support team guarantees continuous service of all products. They will assist you with operating your test device and software, support you during measurements and have answers to all your questions regarding special applications.

Contact Jacques Franken,
Action Instruments,
Tel 011 403-2247, jacques@aisa.co.za

Welcome address by the AMEU president

I would like to thank the Executive Mayor, Councillor Athol Trollip for accepting our invitation to host this year's convention in Nelson Mandela Bay Municipality's beautiful "windy city" of Port Elizabeth.

Our thanks are also extended to all the MMCs and councillors who made time to attend our 66th Convention. We've put together a programme with excellent papers and presentations – we therefore hope that you will find them value-adding.

On behalf of the AMEU, I wish to extend a warm welcome to all of you. Moreover, I wish to make special mention to the Minister of Cooperative Governance and Traditional Affairs, David van Rooyen and his department for the unwavering support they have provided to the AMEU over many years.

I want to make special mention of the council of Nelson Mandela Bay Municipality for supporting the AMEU in hosting this convention.

In deciding on a theme for this year's convention, we deliberated and discussed various options internally and given the challenges facing the membership of the AMEU and our sector, we eventually decided on the theme, "Technical solutions for our changing business model". We wish to answer the question: Is our current business model and energy mix still valid today given the significant challenges facing most of our municipalities?

Given the huge loss of skills and competencies

Moferefere Tshabalala, AMEU president

in our electricity supply sector, especially in metros and municipalities with respect to graduate professionals, there is now an urgent need to upskill our graduate professionals with a focus on female professionals, to ensure that metros and municipalities are able to deliver on their service delivery mandate especially from a technical perspective.

It is evident that the AMEU should give consideration to capacity building, in metros and municipalities through knowledge mentoring, with a focus on increasing employability, and job creation for graduate professionals, especially females.

We have also seen many senior leaders leaving the industry under different circumstances, which is likely to leave a leadership void within the industry. I trust that this will not lead to ineffective governance within the industry as new colleagues are still finding their feet in the new roles with which they have been entrusted. I am positive that these colleagues will be equal to the task and I welcome them to their new leadership roles.

I am particularly happy, that the work started by our immediate past president, Sicelo Xulu, has matured enough to the point that a decision has been taken to incorporate the Women in Electricity (WiE) movement into the main stream of the AMEU thus ensuring that there is only one AMEU conference a year. Thanks for the positive input from the affiliates who contributed to this decision.

WiE has proven to be a strong force within the AMEU, and has made significant progress to the achievement of the goals they had set for themselves. I wish the current WiE leadership success in ensuring that women take their rightful place within the electricity supply industry working side by side with their male counterparts as equals.

I would like to express my heart felt gratitude to the Minister of Cooperative Governance and Traditional Affairs (COGTA) and all political principals present for gracing our convention with their presence.

Moferefere Tshabalala, AMEU president

Welcome address by the host city

After 66 annual conventions, it is clear that the AMEU is here to stay and that it has the magical powers of longevity and the ability to constantly renew and refresh itself, as is also evident from the topic chosen for this convention. I must commend Moferefere Tshabalala, the president of the AMEU, for a carefully crafted and very relevant programme. I am also very happy that one of our own, Paul Gerber of the Nelson Mandela Bay Metropolitan Municipality's Electricity and Energy Directorate, has been granted a spot on the programme.

The Nelson Mandela Bay Municipality is very happy and proud to host this important convention. Energy has been a key focus of this municipality in recent years, and we have in fact been among the pioneering South African municipalities to explore an energy mix, focusing on options in alternative energy,

Councillor Athol Trollip – executive mayor Nelson Mandela Bay Metropolitan Municipality

particularly wind and solar power. The gifts of nature. We are blessed with having sunny, champagne type weather for over 300 days of the year, and of course there are our famous local breezes, which earned us the tag, "the windy city" some decades ago. To our visitors from Cape Town: research has proven that that label is rightfully yours, but let me not create a stir, we love our breezes. They keep the city's air clean and the wind turbines turning.

A highlight of today's proceedings is being addressed by the minister of COGTA, David van Rooyen, and to hear his vision and perspective first hand. The stage is certainly set for an informative and fascinating conference over the next two days.

May this convention rejuvenate and inspire you.

Councillor Athol Trollip, executive mayor, Nelson Mandela Bay Metropolitan Municipality

Keynote address at AMEU Convention 2017

I am glad to note that the conference's theme is "Technical solutions for our changing business model," because it goes to the heart of the challenges currently facing the industry.

A special word of welcome to the President-Elect of the AMEU, Refilwe Mokgosi. When we met her a year ago, the percentage of women in the industry was at a mere 5%.

I am sure that Mokgosi's election will go some way to addressing one of the challenges facing this industry – that of women empowerment and representation.

I look forward to hearing more about your progress in initiatives such as establishing international exchange programmes, continuous professional development programmes and promoting career days and competitions.

Furthermore, I'd like to hear what role we as government and municipalities could play in ensuring the advancement of women in the sector.

There are a number of challenges confronting the industry. The dynamics of power distribution in South Africa is in a fast changing phase and major changes to the way distribution has been done in the past will have to be implemented to keep up with the demand for technology driven systems and procedures.

A few years ago the drive was to implement "smart metering" systems to improve the way metering and distribution intelligence was managed.

Today the drive is changing to a revenue-enhanced focus, where small scale embedded generation (SSEG) will play a major role.

I am glad that the convention makes provision for discussions and information on this very important aspect of the future of electricity utilities in our country.

It is already noted that private individuals are installing solar photovoltaic (PV) panels on their houses and generating power not only as a standby option, but as a way of providing their own grid connected needs.

Before too long these rooftop installations are going to have an impact on the municipal revenue flow and some form of regulation will have to be introduced to protect the national and municipal capital investments in power generation, transmission and distribution.

We hope that by working with institutions such as the South African Local Government Association (SALGA), you will be able to advise us on how to go about this.

Des van Rooyen, Minister of COGTA

Pricing models are already changing, where Eskom is focusing on rationalising the tariff models currently in use.

It will be equally important for the municipalities to be proactive in this regard and adjust the pricing models for distribution of energy to their consumers within the licensed area.

A large capital investment in power utilities by municipalities needs to be looked after through proper maintenance and care taking of these installations.

It is acknowledged by government that municipalities are hampered by the vacant positions for qualified and skilled engineers.

The capacity development programme under the Municipal Infrastructure Support Agency (MISA) addresses this through placing emphasis on the training of artisans, technicians and engineers.

Young engineers will be assisted by a professional team of registered engineers, who will mentor and coach this new generation of engineers to enable registration with the Engineering Council of South Africa (ECSA).

Through this process they will be exposed to the vast number of different maintenance policies, procedures and plans.

They will then be able to pick from these plans the best-suited method to be utilised in their work environment.

This can only have a positive impact on the reliability of the energy supply to the consumer.

Over time there will also be decreased demand for funding for the replacement of deteriorated installations as the networks will be well looked after.

Much research has been undertaken in the provision of alternative energy sources, leading to the development of reliable technology.

In some cases, the existing technology has improved so much that it has become viable to start using these alternative recourses more regularly.

Municipalities should not only focus on solar plants as so-called alternative energy, but should start looking at other resources, such as solid and liquid waste in their towns, from which to generate energy.

More and more private individuals and companies are seeing the benefit of installing solar PV plants and generating energy, which they want to sell, by using wheeling agreements, through the municipal and Eskom transmission and distribution lines.

My question is should municipalities not be leading in this regard and be the frontrunners in this business model?

The business model for generation, transmission and distribution is under pressure as a result of the items mentioned above.

The total national electricity distribution business model is due for review and new and innovative ideas need to be explored, researched and defined to accommodate the future of this industry in a sustainable manner.

Electrical distribution seeks to supply a basic need to the people of South Africa, in terms of the constitution where the use of this resource will be available to all South Africans in a sustainable, affordable and reliable manner.

The long-term outlook for the future cannot be neglected in the endeavour of achieving these goals.

The integrity and durability of the network starts the day the engineer of the future will start his/her design, keeping in mind the cost of ownership from cradle to grave – from installation through utilisation until the equipment is taken out of commission.

As we look to the future and note the impact of decreasing revenue in electricity on the future financial viability of municipalities, let us not make the mistake of ignoring the future.

Let us examine how best we can utilise the opportunities that the future presents.

Des van Rooyen, Minister of Cooperative Governance and Traditional Affairs

CBI-electric: african cables

Power by Innovation...
Innovation through Partnerships

CBI-electric: african cables has been designing and manufacturing a comprehensive range of electrical power cables at their factory in Vereeniging, near Johannesburg, since 1935.

Growth of the manufacturing facility has been consistent with the demand for the product locally while technological advancement has remained abreast of international trends.

Today the company employs over 800 people and can justifiably claim to be a forerunner in the South African cable industry.

CBI-electric: african cables is the first company in the South African cable industry (Category SIC 36300) to obtain accreditation for ISO 9001:2008, ISO 14001 and OHSAS 18001 simultaneously.

CBI electric
african cables

Market leader in the design, development and manufacture of electric power cables

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- Medium Voltage XLPE
- Medium Voltage Paper Insulated cable
- Aerial Bundled Conductor (ABC)
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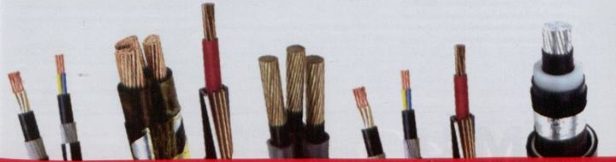
- ACSR
- High Voltage XLPE insulated cable



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Address by NERSA

Congratulations on this stimulating convention held under the theme "Technical solutions for our changing business model". I would also like to congratulate the AMEU for the work it does in promoting uniform approaches and technical excellence in the industry. Conferences such as this are to be valued for their contribution to the industry.

NERSA has a vital role to play in the electricity supply industry and part of that role is the balancing of interests amongst various stakeholders. We are required to execute our mandate without fear or favour.

Likewise, the municipalities have an extremely critical role to play. They are at the coal face when it comes to government's service delivery to the people of South Africa. Among these services is the supply of electricity.

In regulating the municipal electricity supply industry, NERSA endeavours to create an environment where municipalities can achieve their goal of supplying good quality electricity to customers at affordable prices.

To achieve this goal, municipalities need to ensure that the electrical infrastructure is always in good condition, and that electricity departments are adequately staffed so that customers will be treated fairly and justly.

You may be surprised that tariffs are not mentioned here. That is because tariffs are a means to an end and not an end in themselves.

As this is a technical conference, I will now shift my comments to technical issues that are likely to affect the electricity distribution industry.

In 2008, NERSA introduced renewable energy feed in-tariffs (REFITS). The proposed tariff for solar PV was about R4,00/kWh. However, the Department of Energy (DoE) advised NERSA that there is no provision in the Electricity Regulation Act for NERSA to predetermine tariffs. That put paid to the idea of REFITs.

Subsequent to that the DoE initiated the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP). In the first round, the lowest price for PV was R3,00/kWh, however by the fourth round, the lowest price was about R0,99/kWh. That goes to show the price is approaching grid parity. The main reason for the decline in the unit price is the decline in the price of solar panels. It has declined by at least 60% from 2008.

Mbulelo Ncetezo, NERSA

During the same period, we have seen Eskom's average tariff increasing from R0,22/kWh in 2008 to R0,89/kWh in 2017.

Cleary this is encouraging consumers to resort to self-provision through rooftop solar PV installations, which we refer to as small scale embedded generation (SSEG). Thus, consumers are converted to prosumers as there is a possibility for them to export power into the municipality's grid.

As a result, the municipality is faced by at least two challenges: That the legacy networks are not designed for this bidirectional flow of energy, and that municipalities will lose revenue – which is undesirable as the current business model is such that there is an over-reliance on electricity revenues. The introduction of effective and reliable storage technology will exacerbate this situation.

To deal with this possibility, municipalities should redesign their tariffs in such a way that the adverse effect of SSEGs is minimised. The value of the exported kWh cannot be the same as that of the imported kWh. Municipalities should change their business model and the question is how?

An example can be seen from developments in the telecommunications industry. When the cellular phone was introduced, the main service was voice. Today voice is just but one of the services offered by the telecommunication services providers. With the introduction of data services such as internet browsing, WhatsApp, GPS, etc., the main source of revenue is no longer voice.

Thus, the electricity distribution industry should look at ways to transform itself to the point where the sale of kWh will no longer be its main source of revenue.

How can this be achieved? The advent of smart grids, smart meters, smart homes and smart appliances should present an opportunity for this transformation. I envisage a situation where the wires business will be separated from the retail business. The network services business can offer network services to the retailers and the retailers can offer a suite of innovative services to end users. As the share of RE increases in the generation mix there will be a time when some generation plants have to be curtailed to avoid congestion in the system.

One of the services which could be offered by retailers is to switch on smart appliances in smart homes to create a sink for the excess power. The smart meters would then change the applicable tariff to one which would be much lower in line with the excess capacity. Electric cars can also present an opportunity to increase the load.

Smart technologies will obviously require staff who have the prerequisite skills. We know that many municipalities are currently battling to attract and retain skilled staff. To develop the required skills in the right quantities there should be collaboration between the suppliers of skills (TVET colleges and universities) and the municipalities.

The government's role would then be to ensure that policies are in place (e.g. the creation of an enabling market model). NERSA would also be required to ensure that an enabling regulatory framework is in place.

I am looking forward to the deliberations which will take place over the next three days as I believe that this is the right time for them. What we call disruptive technologies are disruptive to the extent that we are not prepared for them.

No one has ever succeeded in either avoiding or resisting new technologies. The only way to survive is to adapt.

Mbulelo Ncetezo, NERSA


INNOVATION DISTINGUISHES BETWEEN A LEADER AND A FOLLOWER
STEVE JOBS
Conlog, a proudly African company, established in 1965, has been at the forefront of pioneering solutions since the inception of the South African prepayment metering industry.
A combination of a superior product range, coupled with a desire to meet and exceed our customer's needs with service excellence has led to Conlog becoming a leader in the market. We specialise in providing Smart Solutions for the delivery of electricity services. Our broad product offer encompasses prepaid and post-paid meters, vending and revenue management solutions, maintenance, support and professional consulting, as well as a dedicated and specialised accredited training facility.
This comprehensive and holistic approach enables customers to reap the full benefit of their investment and ensures sustained success, enabling a smarter future over time.
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Women in Electricity

The AMEU's Women in Electricity (WiE) topic is "Promoting and achieving gender equality within the electricity supply and distribution industries – the journey".

The topic has two aspects: promoting and achieving gender equality.

Promoting gender equality within the electricity supply and distribution industries (qualitative aspect), which I understand refers to initiatives aimed at sensitising the industry to the need and the advantages of gender equality.

This would be a qualitative account of the type of initiatives that are geared at promoting gender equality. It would include among others, policy definition, execution and compliance, covering the entire value chain from university enrollment, positioning of the industry in the minds of female students, recruitment processes, access to on-the-job training, coaching, mentorship and support; environment readiness for accommodating women and working mothers, retention initiatives, progression plans, the participation of men in these projects as well as organisational readiness: values, systems, culture and so on.

Achieving gender equality within the electricity supply and distribution industries (quantitative aspect), which I understand refers to evidence of gender equality in the industry. This is measured by the percentage of women participating at different levels of management in the industry and the reasons for attrition or challenges to retention of women.

Background

In October 2014, the then president, Sicelo Xulu, in his address at the 64th annual AMEU convention stated that a programme was required under the auspices of the AMEU to enable women, particularly African women, to become a critical mass in the electricity generation and distribution sector and to achieve meaningful transformation by identifying the right candidates with the right skills set, and providing coaching and mentoring opportunities to enable them to add value AMEU.

Thus, WiE was established with four key pillars, namely mentorship and leadership development; partnership and networking; international exchange; and talent development.

Today, I am proud to chair this session with great women, women on whose shoulders I stand, industry captains who are also working diligently with WiE to advance its ambitions.

Bertha Dlomini, WiE

In a statement made in 2015, Xulu said that it was unacceptable that 21 years into the new democratic dispensation, that women still played a miniscule role in such a critical sector which is the driving force of economic growth. Driving transformation and fast-tracking women's advancement in the sector is a collective undertaking that requires all the role players to play their part to ensure that women's participation in the sector is meaningful and is enhanced, he added.

According to official statistics women constitute a negligible number of professionals in the sector, accounting for a paltry 5% of the total complement of professionals. African females are less represented and make up a marginal percentage of the aggregate female population in the sector.

Visit to Germany

In 2016, Refilwe Mokgotsi and I were sponsored by Power Africa, a USAID initiative, to attend a workshop in Cologne, Germany, hosted by the United States Energy Association. The workshop was attended by delegates from Jordan, Nigeria, Kenya, Macedonia, to name a few, and looked at gender mainstreaming in utilities in the energy and power sector.

Concerning maternity leave, the following countries offer women the following benefits:

- *Armenia*: 35 weeks, 100% of salary.
- *Russia*: 35 weeks, 100% of salary.
- *France*: 16 weeks, 100% paid, and up to 34 weeks in the event of multiple births.
- *Germany*: 14 weeks leave, 100% paid leave.
- *Japan*: 14 weeks leave, 67% of salary.
- *USA*: 12 weeks leave, benefits granted at state level.
- *Australia*: 18 weeks leave, 100% of salary.
- *South Africa*: 16 weeks leave, benefits granted at unemployment insurance fund (UIF) level.
- *Nigeria*: 12 weeks, 50% of average salary. Civil servants get 6 months fully paid maternity leave.
- *Swaziland*: 12 weeks, only two weeks are paid.

It is important at this point to note that gender equality and participation in the energy sector is about orgainsational success and sustainability; innovation, its advancement and effective execution; and building socially relevant and impactful organisations.

What gender equality is not, even though widely perceived as such, is only a socio-political matter. Neither is it a soft issue.

It is as hard a top line and bottom line matter as is mastering your organisation's balance sheet, and must be seen, believed, and executed as such by both men and women.

Rania Anderson is the author of the award-winning book *Undeterred: The Six Success Habits of Women in Emerging Economies*. She is also a global speaker, an executive business coach and an angel investor in women-led businesses.

Anderson visited South Africa in 2015, and had this to say in an article published by FIN24:

"The research findings are irrefutable: companies with diverse teams and leadership – especially ones that are gender-balanced – produce better results than homogeneous businesses."

The data from around the world is clear: women make the vast majority of consumer purchase decisions, they're graduating from universities more than ever before and they're doing this at rates higher than men.

The current challenges in South Africa are complex. They are economic, social and cultural. To solve complex problems, we need our best and most innovative thinking from the people who best understand these issues.

Continued on page 12...

Round table: Promoting and achieving gender equality

The AMEU's Women (WiE) in Electricity round table discussion highlighted policies and regulations which would support and create a conducive environment for gender equality.

AMEU Women in Electricity, from left to right: Elsie Pule, Sy Gourrah, Makwape Lekganyane, Neli Magubane, Bertha Dlamini, Leba Mashao and Yolanda Mabuto.

Policy and regulations

These policies and regulations exist to support gender equality and mainstreaming in the sector. The challenge is the execution of these policies and regulations at an organisational level. It is critical for companies to create a conducive working environment for women. The World Economic Forum predicts that closing the gender gap will only happen in 2186, and women don't want to wait that long.

The panel said that organisations must have an explicit and deliberate gender-balancing focus on all company projects and accommodate all forms of diversity. In other words, companies and organisations which appoint women should not do so coincidentally or accidentally, but as part of a deliberate plan. Also, women should not only be appointed in support roles such as finance, human resources and administration, but in operational and managerial roles. Furthermore, the panel said, employment must be extended to all demographic groups and sections of the population. Organisations are encouraged to train as many employees as possible, to increase the talent pool.

Entrepreneurship in the energy sector

Basic business skills include time management, correct delegation, cash flow management, client management, marketing, recruitment and practicing best practice, as well as work-life balance.

The energy/power sector is encouraged to promote and support entrepreneurs because SMMEs are expected to become the biggest players in the industry.

Future skills required include ICT, finance, numeracy, communications and collaboration, adaptability, critical thinking, social and cultural awareness. Entrepreneurial skills are also necessary for public officials for them to understand how easily their actions or non-action can compromise the longevity of SMMEs.

Creating solutions for gender equality

The panel said that employers must involve women in creating solutions, and that while strategic direction is required at the top, commitment to execute is critical throughout the organisation. Chief executives were challenged to make the advancement of women a personal mission. This will require continuous monitoring and improvement as necessary. Although mobility is a constant, employers should make a meaningful and compelling case for staff to stay. Retention, the panel said, means giving meaningful work to women, by providing real opportunities for advancement in a diverse environment.

...continued from page 10

Our panelists today will share contextual experiences and views on the topic: "Promoting and achieving gender equality within the electricity supply and distribution Industries – the journey".

Conclusion

Catalyst, a leading nonprofit organisation with a mission to accelerate progress for women through workplace inclusion, reports that Fortune 500 companies with the highest representation of women board directors attained significantly higher financial performance, on average, than those with the lowest representation of women board directors.

The report found higher financial performance for companies with higher representation of women board directors in three important measures:

- *Return on equity*: On average, companies with the highest percentages of women board directors outperformed those with the least by 53%.
- *Return on sales*: On average, companies with the highest percentages of women board directors outperformed those with the least by 42%.
- *Return on invested capital*: On average, companies with the highest percentages of women board directors outperformed those with the least by 66%.

For WiE to succeed in supporting initiatives geared at achieving gender equality within the electricity supply and distribution Industries, it needs the support and participation of leaders with courage tenacity and fortitude to dismantle the archaic portraits of what women should be, and to replace that with refreshed portraits of what women can be. Leaders with the inspiration to transform, transition and traverse the change trajectory to become an inclusive organisation where employees representing every dimension of diversity can thrive.

Bertha Dlamini, Women in Electricity


Gordon Arons, Chairperson AMEU affiliates.


Vally Padayachee, AMEU strategic advisor.


Stan Bridgens (right) receiving his honorary membership award from Moferefere Tshabalala.


Roelof du Toit (right) receiving his honorary branch award from Moferefere Tshabalala and Johan du Plessis.


Sicelo Xulu (right) receiving his honorary membership award from Moferefere Tshabalala.


Dawie van Niekerk (right) receiving his honorary membership award from Moferefere Tshabalala and Gordon Arons.


Aurelie Ferry (centre) won the AMEU Best Paper Award.


Geeven Moodley (centre) won the AMEU Best Paper Award


Schneider Electric won the Best Large Exhibition Stand Award.


Aberdare won the Best Medium-Sized Exhibition Stand Award.

Nugen won the Best Small Exhibition Stand Award.


AMEU executive council.

Change of business models in municipalities: Models for mixed energy distribution utilities

by Mokgadi Magemba, City Power; H van Jaarsveldt, Matleng Energy Solutions; and R Evert, Pendo Energy Solutions

Most utilities have based their operational business on the monopolisation business model which only allows streamlining their business to the distribution of electricity rather than energy. This model assumes that there are no competitors or alternatives and one remains the distributor within their area of supply forever. Utilities never anticipated that energy can even be contained without affecting the utilities network, for example liquid petroleum and natural gas, and made rules that only safeguarded their electricity distribution. Eskom highlighted its capacity challenges but utilities lacked the will to assist in overcoming them and were caught off guard when consumers outsmarted them regarding alternative energy sources.

Current business models used by supply authorities within South Africa are not addressing complete solutions for the migration from electricity companies to energy companies. To become energy utilities, an approach must be formulated addressing the transition needs.

Several mixed energy solutions can be considered for the migration to a complete energy utility. The mixed energy solutions will be unique to each region of South Africa due to environmental, financial and logistical elements.

The current capability and skills level of the various supply authorities must be addressed in order to ensure that the proposed mixed energy solutions are implemented successfully and maintained, ensuring a sustainable energy future for the supply authorities.

The proposed solution presented in this paper is a tailored solution for the middle income class, integrating electrical grid, gas and solar PV/thermal as a mixed energy package for consumers.

Background

Mixed energy packages

Most utilities have based their operational business on the monopolisation business model which only allows streamlining their business to the distribution of electricity rather than energy. This model assumes that there are no competitors or alternatives and one remains the distributor within their area of supply forever. Utilities never anticipated that energy can even be contained without affecting the utilities network, for example liquid petroleum and natural gas, and made rules that only safeguarded their electricity distribution.

Eskom highlighted its capacity challenges but utilities lacked the innovative will to assist in overcoming these capacity challenges and they were caught off guard when consumers outsmarted them regarding alternative energy sources.

The current energy status quo within South Africa encourages supply authorities to merge from electricity utilities to energy utilities by implementing different sources of energy to meet the demands of consumers. The local market is flooded with renewable energy solutions for residential applications and if municipalities don't adapt to mixed energy requirements, they might be left behind with individuals catering for their own needs by implementing alternative energy solutions.

The proposed mixed energy packages presented in this paper aim to pave the way for municipalities to merge to energy utilities by integrating alternative energy sources, including gas and solar PV/thermal (see Fig. 1).

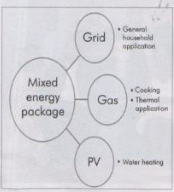

Fig. 1: Proposed mixed energy package.

The approach presented in this paper focuses on the integration of a mixed energy solution with gas for cooking and thermal application, solar PV for water heating purposes and electrical grid for general household application.

South African middle class

Household income classification is an economic measure that can be applied to a large group of households across a country. The classification is commonly used to describe a household's economic status or track economic trends within a country [1].

Statistics South Africa Report No. 03-03-01 for Profiling South African Middle Class Households 1998 – 2006, defines middle class household as households living in formal housing, running water in dwelling, flush toilet in dwelling, electricity as main light source, electricity or gas as main cooking source and households with a landline phone or a household member with a cell phone [2].

The classification of households is often compiled based on the income of the specific household. The Bureau of Market Research (BMR) puts the annual income classification of South Africa as shown in Table 1.

The South African middle class comprises approximately 18% of the working population. The middle class in South Africa also generates the most income compared to the other income classes. If an individual

Annual income	Monthly income	Classification
R0 – R11 600	R0 – R967	Lowest
R11 601 – R49 000	R968 – R4083	Second lowest
R49 001 – R109 000	R4084 – R9083	Low emerging middle
R109 001 – R234 000	R9084 – R19 500	Emerging middle
R234 001 – R378 000	R19 501 – R31 500	Lower middle
R378 001 – R783 000	R31 501 – R65 250	Upper middle
R783 001 – R1 693 000	R65 251 – R141 083	Upper income/emerging afluent
R1 693 001+	R141 084+	Affluent

Table 1: Household income classification for South Africa [3].

lives in a more urbanised province such as Gauteng, the probability that they are in the middle class is 21%. This is better compared to less urbanised provinces such as the Northern Cape where the probability is 16% [4]. The mixed energy packages discussed in this paper are focused on the middle class of South Africa.

Census SA estimated the Gauteng population to be 13 399 725 in 2016 [5]. The number of households also increased over the past few years to more than 500 000. This then accounts to approximately 2 813 943 individuals or 105 000 households within the middle class currently living in Gauteng. Fig. 2 depicts the different Income classes within Gauteng.

The graph graph in Fig. 3 indicates a projected steep rise in the middle class category of South Africa between 2016 and 2026. This can be exploited for potential increase in revenue and improved innovation relating to the energy space for supply authorities.

The projected increase in the middle class must be seen as an opportunity for supply authorities to empower the consumers with alternative energy technologies that are available. The implementation of complete energy packages will have benefits to both supply authority and consumer.

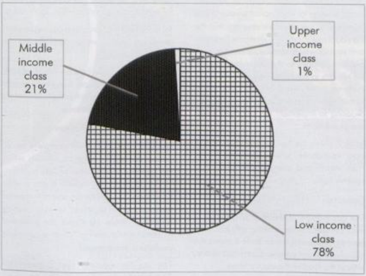

Fig. 2: Gauteng – household income classes.

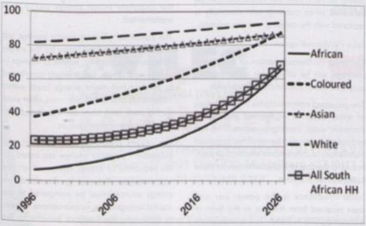

Fig. 3: Projected growth of middle class [2].

Mixed energy packages

The proposed approach entails the formation of energy packages utilising the various available alternative energy sources. Consumers will then be able to purchase energy packages comprising units of energy from the various sources, including grid electricity, gas and solar PV/thermal. The idea is for municipalities to implement similar contracts currently available in the telecommunication sector where a consumer pays a predetermined amount and receives airtime, SMS, and data based on the package on offer.

The successful implementation of the proposed energy packages is dependent on a number of key elements. The current metering topologies used by municipalities must be investigated in order to determine if the topologies are able to address the metering required for the energy packages.

Municipalities should also review current energy tariffs and implement tariff structures with specific focus on addressing the unique energy mix solutions comprising multiple sources of energy.

The implementation of an energy package, including a mix of grid electricity, gas and solar PV/thermal, will promote the move from electricity utilities to complete energy utilities. The packages should be structured by the municipalities to have maximum benefits for both supply authority and the consumer.

Business model

As per the AMEU report on the guideline on the installation of embedded generation and the impact it may have on the revenue of municipalities dated 5 October 2013, it already shows that much work has been done on analysing the impact of renewables and embedded generation [6].

From the report the following is to be noted from the City Power case study as highlighted that under business as usual (BAU) conditions, i.e. no major changes to tariff structures over the next ten years, embedded and renewable energy will decrease City Power's revenue base by 2,28%. The residential sector is responsible for approximately 50% of the total City Power revenue (see Tables 2 and 3).

The same report proposed the following strategic financial cases for interventions. SEA has undertaken a range of EE and RE intervention cost-benefit analyses. These determine the financial payback of each intervention, taking the following factors into consideration:

- Full installed cost of intervention.
- Current tariff specific to sector (residential, commercial, industrial).
- Tariff increase of 8% per year.
- Financial attractiveness of the intervention to the end user based on cash up front repayment, bond repayment (8,5% interest over ten years and retail bank loans 18% over five years

	Customers above 600 kWh/month	PV uptake in year 10	SWH uptake in year 10	EE uptake in year 10
Residential	269 169	44 221	160 639	160 369
Commercial	7335	4148	0	500
Industrial	4005	674	0	2332

Table 2: Projected uptake of RE and EE.

	Low demand	High demand
Peak	07h00 – 10h00	06h00 – 09h00
	18h00 – 20h00	17h00 – 19h00
Standard	06h00 – 07h00	09h00 – 17h00
	10h00 – 18h00	19h00 – 22h00
Off-peak	22h00 – 06h00	22h00 – 06h00

Table 4: Eskom TOU structure – Weekdays [7].

	Impact on revenue (%)	Impact on revenue (R)
Residential	-1,11%	-R558 231 401
Commercial	-0,56%	-R281 823 107
Industrial	-0,61%	-R305 886 623
Total	-2,28%	-R1 145 941 131

Table 3: Impact of RE and EE on City Power revenue.

	Low demand	High demand
Peak		
Standard	07h00 – 12h00	07h00 – 12h00
	18h00 – 20h00	18h00 – 20h00
Off-peak	12h00 – 18h00	12h00 – 18h00
	20h00 – 07h00	20h00 – 07h00

Table 5: Eskom TOU structure – Saturdays [7].

The strategy that will be proposed in this paper is based on the full installed cost of intervention only addressing the middle class.

Time of use (TOU) tariff structure

The proposed mixed energy packages will yield maximum benefits for both consumer and supply authority with the implementation of a time of use tariff structure. Tables 4 to 6 illustrate the time of use structure currently used by Eskom. Supply authorities can use this structure as a guideline in formulating their own or adopt the current structure as is.

The motivation for the implementation of a time of use structure is based on the principle of rewarding consumers who make use of the mixed energy packages. The peak tariffs for both seasons fall on weekdays, in the following time slots: 07h00 – 10h00; 06h00 – 09h00; 18h00 – 20h00 and 17h00 – 19h00.

The average households falling within the middle class will typically prepare food within these times. A normal consumer, with only grid supply, will therefore pay more per energy unit (kWh) for cooking. This will act as motivation for the implementation of the mixed energy packages where cooking will be by means of gas, reducing the electrical load of the consumer during peak periods.

Case study

Introduction

Although the mixed energy packages can be tailored for all income classes in South Africa, the information presented in this paper will focus on the middle class.

The tariff structure used for the purpose of this proposal is based on the City Power approved tariffs for 2016/2017 for a domestic prepaid 230 V, 60 A, consumption from 501 to 1000 kWh at 129,03 c/kWh [8].

Different municipalities will each have their own tariff structures, making the potential energy savings for each option unique to that municipality. It is therefore essential that the individual municipalities investigate their own tariff structures to determine potential savings and formulate new tariff structures to maximise the benefits to the consumers. The proposed implementation of time of use structures can further assist in creating benefits to consumers choosing to implement the proposed mixed energy solutions.

Table 7 shows the typical load for a middle class household, with subsequent energy consumption and energy expenditure on a monthly basis.

Gas option

The gas portion of the energy package is meant to replace the cooking with electricity from the residential loads. Table 8 shows the typical energy consumption presented above, without the load of the electric stove.

From the table it can be seen that a monthly saving of 76,1 kWh per household can be achieved when cooking with electricity is replaced with the cooking with gas solution.

Solar PV/thermal option

The solar PV/thermal portion of the energy package will be utilised for water heating purposes within middle class households.

The proposed option includes the installation of either solar PV or thermal geysers for domestic water heating purposes. The two technologies can also be retrofitted to current installations of conventional electrical geysers, reducing the cost of implementation for these options.

Solar irradiance is the power per unit area received from the sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument. The majority of South Africa has good solar irradiance, rendering this a suitable option for most supply authorities within South Africa.

Table 9 shows the typical energy consumption presented above, without the load of the electric geyser.

From the table it can be seen that a monthly saving of 237,3 kWh per household can be achieved when solar PV/thermal is utilised for the water heating purposes.

Complete mixed energy option

The aim is to implement complete mixed energy packages for the households within the middle income class of South Africa. These packages will include a gas portion for cooking as well as the solar PV/thermal package that will be utilised for water heating purposes. Table 10 shows the potential monthly energy savings when a complete package is implemented.

The results indicate that a potential 313,3 kWh of grid energy can be saved on a monthly basis per household when the complete mixed energy package is implemented.

The combined effect of energy savings will yield an improved load factor for the supply authority which, in turn, relates to savings in energy expenditure. This is largely contributed to the fact that major energy loads within households and specifically ones often used during peak load times are substituted with the alternative energy sources.

The results presented in the tables and subsequent potential savings are based on the reduction of energy consumed on the electrical grid. The cost for the alternative energy sources must be compared to the capital savings of the various options in order to determine the financial benefits to the individual consumers.

	Low demand	High demand
Peak		
Standard		
Off-peak	00h00 – 24h00	00h00 – 24h00

Table 6: Eskom TOU structure – Sundays [7].

Fig. 4 shows the potential monthly reduction of grid energy for each of the packages discussed above.

Proposed implementation of the full installed cost of intervention

Utilities have the opportunity to get revenue on the savings made from the proposed savings approach (see Table 11).

Should the consumer exceed 150 units a month to top up, a unit will be charged at 159,00 cents per kWh (see Table 12).

Should the consumer exceed 100 units a month to top up, a unit will be charged at 190,00 cents per kWh (see Table 13).

Should the consumer exceed 60 units a month to top up a unit will be charged at 200,05 cents per kWh.

A monthly maintenance fee of a percentage of the assets financed must also be calculated and added to the monthly repayment. This fee must cover all repairs to the equipment during the finance term.

This calculation will be done once the supplier's guarantee period is stablished.

Success factors

The successful implementation of the proposed mixed energy packages rests on a number of issues to be addressed, including:

Tariff analysis

The analysis of energy tariffs will determine the energy mix combinations and highlight the preferred time of use.

It is important for individual municipalities to review their current tariff structure in order to determine a new structure that will benefit both consumer and supply authority with the implementation of the proposed mixed energy solutions.

Load factor

The implementation and correct use of the mixed energy packages must yield an improved load factor for the supply authority. This, in turn, will result in overall lower cost of energy which can be translated to lower energy tariffs for consumers.

Community education

The success of the proposed packages largely rests on the correct use of the individual energy technologies. Therefore, the community education becomes a critical element where consumers will have to understand both the new technologies implemented, as well as how and when the different technologies should be used to obtain the required results.

System support

Appliance	Power rating (W)	Daily use (h)	Daily consumption (kWh)
Stove (hob)	1500	1,0	1,5
Stove (oven)	2000	0,5	1,0
Geyser	3000	2,6	7,8
Fridge	385	2,0	0,8
Freezer	150	4,0	0,6
Dishwasher	2500	0,9	2,3
Tumble dryer	3300	0,2	0,7
Washing machine	3000	0,2	0,6
Television	200	3,5	0,7
Additional	1945	2,5	4,9
Household lighting	1250	5,0	6,3
Daily energy consumption (kWh): 27,0			
Monthly energy consumption (kWh): 821,1			
Monthly energy expenditure: R1059,22			

Table 7: Normal middle class household.

Appliance	Power rating (W)	Daily use (h)	Daily consumption (kWh)
Stove (hob)	1500	0	0
Stove (oven)	2000	0	0
Geyser	3000	2,6	7,8
Fridge	385	2,0	0,8
Freezer	150	4,0	0,6
Dishwasher	2500	0,9	2,3
Tumble dryer	3300	0,2	0,7
Washing machine	3000	0,2	0,6
Television	200	3,5	0,7
Additional	1945	2,5	4,9
Household lighting	1250	5,0	6,3
Daily energy consumption (kWh): 24,5			
Monthly energy consumption (kWh): 745,1			
Monthly energy expenditure: R961,179			

Table 8: Gas only option.

Appliance	Power rating (W)	Daily use (h)	Daily consumption (kWh)
Stove (hob)	1500	1,0	1,5
Stove (oven)	2000	0,5	1,0
Geyser	3000	0	0
Fridge	385	2,0	0,8
Freezer	150	4,0	0,6
Dishwasher	2500	0,9	2,3
Tumble dryer	3300	0,2	0,7
Washing machine	3000	0,2	0,6
Television	200	3,5	0,7
Additional	1945	2,5	4,9
Household lighting	1250	5,0	6,3
Daily energy consumption (kWh): 19,2			
Monthly energy consumption (kWh): 237,3			
Monthly energy expenditure: R306,12			

Table 9: PV only option.

As this will be new for most supply authorities within in South Africa, system support is crucial in order for both supply authority and consumer to work together. This support includes systems like gas depots and PV maintenance teams.

Operation and maintenance

In order to ensure that the integration of alternative energy sources with the current electrical grid is sustainable, municipalities will have to implement appropriate operation and maintenance procedures specific to each technology type.

The alternative energy technologies will be new technology for most municipalities. The municipalities will therefore need to address training programmes in order to ensure that they empower their employees to handle the maintenance and operation of the new technologies.

Funding models and financial legislation

Funding for the proposed mixed energy solution is vital as the technology proposed can be expensive and therefore consumers might not be able to pay the upfront cost for the installation of the equipment. One potential solution is to provide a lease to own option for consumers. The consumer will then pay a predetermined amount at regular intervals until such time when the package is repaid to the municipality.

Financial legislation is therefore vital in order to understand what funding models can be pursued by supply authorities in an attempt to make the options financially more attractive and affordable to consumers.

Cross subsidisation

Cross subsidisation is the practise of charging higher rates to one group of services to subsidise lower rates for another group. The current tariff structures of municipalities must be revised in order to allow for cross subsidisation to benefit those consumers who implemented one of the proposed packages. This will then act as a further incentive motivating consumers to opt for the mixed energy packages, in turn assisting the municipalities with their transformation to complete energy utilities.

Time of use structures

One of the major benefits to consumers should be an overall lower cost of energy. This can be accomplished with the implementation of time of use structures where the consumer will utilise alternative sources of energy within peak periods to avoid high electricity tariffs. This is key to making a mixed energy solution a success.

Incentives

Without firm motivation, consumers will not substitute their current supply of energy from conventional grid electricity as this will hold minimal to no benefits for them. With the correct incentives, including the proposed cross subsidisation, funding models and time of use tariff structures, consumers will realise that the options hold actual benefits, motivating the implementation of the proposed solutions.

Back office requirements

The back office of the supply authorities will generally handle the administrative aspects

Appliance	Power rating (W)	Daily use (h)	Daily consumption (kWh)
Stove (hob)	1500	0	0
Stove (oven)	2000	0	0
Geyser	3000	0	0
Fridge	385	2,0	0,8
Freezer	150	4,0	0,6
Dishwasher	2500	0,9	2,3
Tumble dryer	3300	0,2	0,7
Washing machine	3000	0,2	0,6
Television	200	3,5	0,7
Additional	1945	2,5	4,9
Household lighting	1250	5,0	6,3
Daily energy consumption (kWh): 16,7			
Monthly energy consumption (kWh): 507,8			
Monthly energy expenditure: R655,06			

Table 10: Complete mixed energy option.

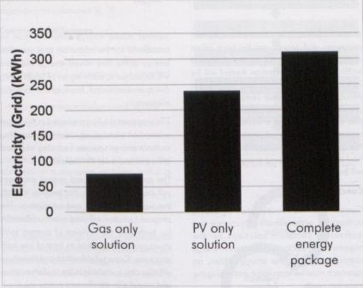

Fig. 4: Estimated electricity savings.

Package option	Cost	Monthly repayments (8%, 60 Months)
Gas stove	R3700,00	R75,00
Gas bottle (6 kg filled)	R680,00	R13,00
Gas installation including COC	R690,00	R13,00
Finance admin cost		R68,00
Additional gas (1 kg = 13 kWh)	6 kg gas x R19/kg	R114,00
Grid monthly units of 150 @ 129,03c	R193,54	R193,54
Total monthly repayments		**R476,54**

Table 11: Grid and gas.

Package option	Cost	Monthly repayments (8%, 60 months)
PV geyser high pressure 150 litres	R17 000,00	R344,00
Finance admin cost		R68,00
Grid monthly units of 100 @ 129,03c		R129,03

Table 12: Grid and PV.

Package option	Cost	Monthly repayments (8%, 60 months)
Gas stove	R3 700,00	R75,00
Gas bottle (6 kg filled)	R680,00	R13,00
Gas installation including COC	R690,00	R13,00
Finance admin cost		R68,00
PV geyser high pressure 150 litres	R17 000.00	R344,00
Additional gas (1 kg = 13 kWh)	6 kg gas x R19/kg	R114,00
Grid monthly units of 60 @ 103,22c		R 77,41
Total monthly repayments		**R704,41**

Table 13: Grid, PV and gas.

of the business. It is vital that the correct processes and procedures for back office support is implemented as the proposed technologies and integration thereof will be new to most or all municipalities within South Africa. The administrative component of the proposed business model is essential to ensure that the utilities ensure a sustainable mixed energy future within South Africa. Monitoring the system through the back office to establish how successful the mixed energy solutions is will be crucial.

Conclusion

Current business models used by supply authorities within South Africa are not addressing complete solutions for the migration from electricity companies to energy companies. To become energy utilities, an approach must be formulated addressing the transition needs.

Several mixed energy solutions can be considered for the migration to a complete energy utility. The mixed energy solutions will be unique to each region of South Africa due to environmental, financial and logistical elements.

The proposed solution presented in this paper is based on a total energy package integrating multiple energy sources, including electrical grid, gas and solar PV/thermal.

The success of the mixed energy packages will depend largely on the benefits to both the supply authorities and consumers. The proposed solution will yield maximum benefits for both with the revision of current tariff structures and migration to time of use tariff structures. Cross subsidisation and incentives will also play a vital role in the implementation and overall success of mixed energy solutions.

The proposed solution presented in this paper can be implemented successfully only after all issues discussed in the success factors section of this paper are addressed.

References

[1] The World Bank: "New country classifications by income level", 1 July 2016. [Online]. Available: https://blogs.worldbank.org/opendata/new-country-classifications-2016. [Accessed: August 2017].

[2] Statistics South Africa: "Profiling South African middle-class households", 1998 – 2006, Report 03-03-01, ISBN 978-0-621-39028-8, 19 January 2010.

[3] BusinessTech: "What you need to know about South Africa's middle class", 12 May 2016. [Online]. Available: https://businesstech.co.za/news/banking/123511/what-you-need-to-know-about-south-africas-middle-class/ [Accessed: July 2017].

[4] BusinessTech: "How South Africans generate an income", 14 May 2016. [Online]. Available: https://businesstech.co.za/news/general/123493/how-south-africans-generate-an-income/ [Accessed: July 2017].

[5] City Population, Gauteng South Africa, 29 July 2016. [Online]. Available: www.citypopulation.de/php/ southafrica-admin.php?adm1id=7. [Accessed: August 2017].

[6] Embedded Generation: AMEU report: "Guideline on the installation of embedded generation and the impact it may have on the revenue of municipalities", the Association of Municipal Electricity Utilities (Southern Africa), 5 October 2013.

[7] Eskom: "2017/18 tariffs and charges", [Online]. Available: www.eskom.co.za/CustomerCare/ TariffsAndCharges/Pages/Tariffs_And_Charges.aspx [Accessed: August 2017].

[8] City Power Johannesburg: "FY2016/17 tariffs", [Online]. Available: www.citypower.co.za / customers/Pages/Tariff-Info.aspx [Accessed: August 2017].

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Change of business models in municipalities: Operation and maintenance

by Lomile Modiselle, City of Tshwane

The condition of municipal electrical infrastructure in South Africa is a crucial element in our ability to ensure service provision to all communities. This paper will look into the state and performance of municipal infrastructure, the state of its maintenance, and the underlying causes of this state of maintenance and challenges facing municipalities. The aim is to also identify priorities that could be taken to improve the maintenance of municipal infrastructure by identifying maintenance priorities to be attended to, and then to initiate or facilitate a process whereby the necessary actions could be taken by appropriate role-players.

Maintenance and refurbishment of municipal infrastructure is among the commonest operation and activities to improve the system reliability and components availability [1, 2].

The purpose of maintenance and refurbishment is to ensure that an asset maintains its ability to operate reliably and safely (the same as maintaining your motor vehicle). In terms of the Occupational Health and Safety Act, electricity utilities are obliged to create a safe environment for their employees and their communities [3]. Unmaintained electrical assets become time bombs waiting to explode.

Municipalities are expected to deliver quality power to the customers that spend their hard-earned money on acquiring the services. With well-maintained lighting infrastructure the communities and roads are kept safe. Municipalities need to ensure that assets are operated within their limits and thus extending the reliable life span. Poor quality of supply damages the appliances in industries, homes, etc. Electricity outages due to poor maintenance causes inconveniences from no electricity in our homes to traffic disruptions, resulting in loss of production. Infrastructure management is likened to the configuration of value creation or value chain element [4] and reliable infrastructure is the building block of successful nations.

Maintenance and refurbishment need to be planned properly to be cost effective and offer value for money [5].

(E.g. Maintaining the batteries in a substation can cost as little as R10 000 to R50 000 per year per substation. Not maintaining it can cause damage in excess of a R100-million per occasion) – Not wise to neglect! Thus, it is important to prioritise maintenance to be affordable and within budgeted cost.

Hence, maintenance is still considered as an obligatory cost instead of part of process optimisation [6]. However, the main challenges that restrict maintenance development are insufficient measuring, lack of development (e.g. improvement of our training processes, development of old and experienced employees), lack of mutual trust, lack of communication and communication of systems technical solutions etc. including integration of different systems, timing problems for larger maintenance breaks and a primitive mind set in understanding and organising maintenance [6, 7].

Common challenges

In this section, various issues and challenges associated with development and implementation of maintenance are identified and discussed.

Limited maintenance budgets and funding

The determination of the cost for maintenance work in municipal infrastructure has always been problematic between the maintenance contractor and the client. Worsening the scenario, it is always a problem and it is usually a very hard task to determine the exact cost of maintenance works such as repairs, replacement, or internal maintenance works [8].

Most research findings show that maintenance is not carried out according to actual need, but based on the allocated budget without making a careful evaluation of the actual needs of the maintenance work [9]. Consequently, insufficient maintenance budgets are the main concern which restricts the maintenance procedures being performed well.

Lack of resources

The main problems facing municipalities is lack of manpower, materials, equipment, transportation, etc.

Lack of knowledge/skills

One of the most important concerns in municipalities is the experts' knowledge and expertise which can directly affect the maintenance quality and performance. Lack of skills and technical know-how personnel caused by the loss of intellectual assets and key technical staff, and their non-replacement, or replacement by others who are less qualified or experienced, remains a challenge with development and implementation of maintenance across municipal infrastructures.

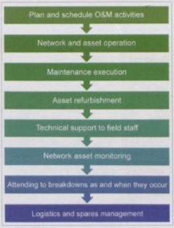

Fig. 1: Steps to operate and maintain an asset.

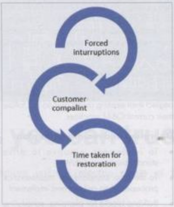

Fig. 2: Compliance with NRS 047 [11].

Bias of funding new assets and projects:

Most municipalities emphasise or prioritise the budgets into construction of new assets. However, a complementary and more effective approach is to improve utilisation and longevity of the existing infrastructure and to make the most of existing assets by means of optimal operaton and maintenance (O&M). Again, maintenance is neglected since the political bias is towards funding the

Inspection	Measured	Cycle	#Items	Lab + Tra	Tot
Mini subs	per M/S	3 yrly	291	1347,06	391 994,46
Subs cleaning	per M/S	x10 yrly	291	1347,06	391 994,46
RM6,RM8	per M/S	3 yrly	28	1347,06	37 717,68
T3	per S/gear	3 yrly	18	1347,06	24 247,08
T4	per S/gear	3 yrly	10	1347,06	13 470,60
ODS	per item	3 yrly	33	1347,06	44 452,98
CLC	per item	3 yrly	3	1347,06	4041,18
Satellite subs	per item	x10 yrly	7	1347,06	9429,42
Meter boxes	per box	1 yrly	3918	1347,06	5 277 781,08
LV OHM	per Km	1 yrly	898 km	449,02	5 040 249,50
MV OHM	per Km	1yrly	387 km	449,02	2 172 134,25
					13 407 512,69

Table 1: Example of a preventative maintenance plan.

Province	20%	20 – 30%	30 – 50%	50 – 75%	75 – 100%	Total
Gauteng	0	0	1	5	4	10
NW	0	0	2	5	7	14
NC	0	0	2	3	19	24
FS	3	1	1	5	10	20
KZN	0	0	0	4	21	25
EC	0	0	2	4	22	28
Limpopo	0	1	1	3	11	16
MP	11	3	0	1	0	15
WC	0	0	0	2	23	25
Total	14	5	9	32	117	177
	8%	3%	5%	18%	66%	100%

Table 2: Vacancy rate statistics in electricity departments for all municipalities.

new projects. As a result of this maintenance backlog, and the lack of resilience measures, the existing assets deteriorate much faster than necessary which leads to a shorter life span.

Negligence to O&M practices

In many instances, majority of municipalities neglect their existing assets and do not follow their current O&M practices.

Operating and maintenance plan

- To implement initiative to drive standardisation in O&M.
- To develop standardised maintenance processes, then roll out and implement
- Building blocks for planning, scheduling and execution established.
- Quicker to introduce maintenance monitoring and drive improvement.
- Cultural change of various building blocks – little effort required for doing the "correct things."
- Establishes asset management thinking.

Steps to operate and maintain an asset

Around the world, many countries are experiencing severe infrastructure needs because of growing populations, economic growth, urbanisation, and aging legacy assets [10]. To meet up with these demands, most governments emphasise constructing new assets, but this imposes a great challenge due to public budget constraints. A potentially more cost effective approach is to improve the utilisation, efficiency, and longevity of the existing infrastructure stock. Fig. 1 shows steps to operate and maintain an asset.

Maintenance strategies

The common strategies used by many municipalities are preventative and corrective maintenance; however, it will be difficult to follow the maintenance as per Table 1 below due to (funding, lack of resources and High vacancy rate etc.). The below maintenance plan will be expensive when only utilising persons but not monitoring systems.

Example of preventative maintenance plan

Fig. 3 analyses the time spent on preventative maintenance of Table 1 equipment.

Changing business model

Implementation of best practices

Maximise asset utilisation

- Reduce losses by harnessing leakage detection technology and invest in new equipment.

Improving reliability and quality of electricity supply

- Enhance compliance with both NRS 047 & NRS 048 (see Fig. 2).

Reduce maintenance cost

- By using new technologies (e.g. remote assets inspection); autonomous operations and integrated scheduling and systems control.
- In the case where requisite technology is discouragily expensive, or where specialised skills would be needed, municipalities may opt to outsource maintenance works or IT services so that they can realise major cost savings.

Mitigate externalities

- Environmental and OHS impact – an inefficient maintenance performance can lead to incidents, accidents and other health hazards.

Extend asset life

- Introduce new technology that can bring about sensors and embedded technology, information and communication technology (ICT) and condition-based inspection technology like vibration, spectroscopy, thermography and others, which are replacing preventive maintenance with predictive maintenance.
- Asset management according to its specification to control excessive usage or consumption.
- Identify and do risk assessment, develop plans and incorporate more resilience into existing assets in the case of natural disasters.
- Again, ensure that the physical assets perform as per design [12].

Fig. 4 is a bathtub curve, which shows that in the early life of the equipment adhering to the bathtub curve, the failure rate is high but rapidly decreasing as defective products are identified and discarded, and early sources of potential failure such as handling and installation error are surmounted. In the mid-life of a product generally the failure rate is low and constant. In the late life of the product, the failure rate increases, as age and wear take their toll. Some equipment depreciates faster due to them being overloaded to more than their capabilities [13].

Reinvest with a life cycle view

- Most of our infrastructure/assets were constructed a long time ago and need to be replaced or refurbished as they are approaching the end of their life cycle.
- Replacement/refurbishment should consider cost benefit analysis and lifecycle cost analysis (e.g. include those technologies mentioned above on inception of new projects).
- This will see the true cost of initial construction higher than the cost of operation and maintenance.

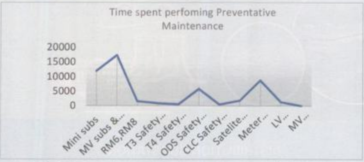

Fig. 3: Graph showing the time spent on preventative maintenance of table 1 equipment.

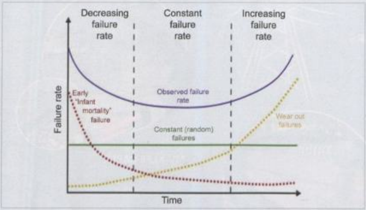

Fig. 4: The bathtub curve [13].

- Introduce greener infrastructure facilities with energy savings, etc.

Implementation of asset management

Asset management: systematic and coordinated activity and practice through which a utility optimally manages its assets, and their associated performance, risks and expenditures over their life cycle for achieving the utility's organisational strategic plan.

- The main purpose of asset management implementation is managing and balancing the cost, risk and life expectance of a particular asset.

Asset monitoring

- Record all past failures
- Calculate frequency and impact of failures
- Prioritise the assets in a risk classification matrix
- Customise maintenance strategy for each asset/be equipment-specific
- Identify standard procedures [14]

Asset lifecycle stages

An asset life cycle includes all the stages that an asset experiences over its life. In some organisations assets are purchased, used and disposed of while others, such as roads, have no realistic end of life stage [15]. Fig. 5 shows stages of asset lifecycle.

Successes through installation of computerised systems

The SCADA system proved to be an extremely valuable operational tool and coupled with the load restoration software packages, is instrumental in reducing outage times significantly during several major faults. The control staff can respond more rapidly to these situations than they could in the past. It is no longer necessary to call out field staff to perform switching operations on these occasions, such operations can be performed remotely by the control staff instead.

Benchmarking

Different municipalities already apply some of these O&M best practices, many others fail to achieve anything near the full optimisation potential. They should begin by systematically reviewing and benchmarking their O&M practices and policies against the complete best practice with other municipalities.

Case study

SALGA released the vacancy rate statistics in electricity departments for all municipalities for 2015/2016 financial year [16] as shown in Table 2 and Fig 5.

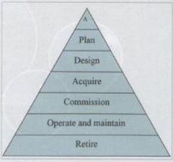

Fig. 5: Stages of asset management.

Conclusions

Below is an indication of where and how to start and what to allow:

- Identifying assets to maintain; such as a substation, where asset failure causes major damages and loss.
- Identify assets where failure may cause loss of limbs or life.
- The compliance with all relevant legislation.
- To provide a quality service delivery.

Municipalities need to develop a holistic and long-term strategy for operating and maintaining their physical assets that may represent a considerable financial burden for future taxpayers.

If existing infrastructure is not well-maintained, municipalities often face a costly conundrum of political and social pressures to pursue much costlier greenfield projects, some of which may have been avoided (or at least postponed by several years) if rigorous approaches to maintenance had been implemented from the outset. Given the general state of fiscal constraints prevailing in the country today, the importance of O&M aspects is brought into stark relief.

Finally, it is crucial to remember that proper O&M is part and parcel of high-quality service orientation for users, and this user-based focus is what drives their willingness to pay for services and thus underpins funding sustainability. As such, effective O&M and asset management approaches for existing infrastructure provide a blueprint for sustainable greenfield investment in future.

Various information systems were investigated and proved to be forming part of effective process and the best solution to maintain the municipal infrastructure.

Recommendations

Municipality leadership should:

- Apply the 20/80 principle: identify areas where 20% money spend can have an

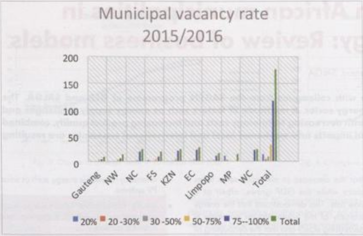

Fig. 6: Vacancy rate statistics in electricity departments for all municipalities.

80% reliability and cost saving impact on the network.

- Ensure stable and sufficient funding for O&M of the mentioned priorities.
- Build capabilities by ensuring asset management planning, ensure training and development talent and attach this staff for longer time.
- Reform governance by ensuring cooperation between agencies, consider private sector participation and competition.

References

[1] P Dehghanian, M Fotuhi-Firuzabad, S Bagheri-Shouraki, and AA Razi Kazemi, "Critical Component Identification in Reliability Centred Asset Management of Power Distribution System via Fuzzy AHP," IEEE Systems Journal, vol. 6, no.4, pp.593-602, Dec. 2012.

[2] P Dehghanian, M Fotuhi-Firuzabad, S Etezad Moghimi Tavanir, and M Sadeghi Khomanmi Tavanir, "Investigation of the current maintenance experience in power distribution utilities of IRAN," 22nd international conference on electricity distribution, 10-13 June 2013.

[3] RL Brauer, 2016. Safety and health for engineers. John Wiley & Sons.

[4] CA Gabriel and J Kirkwood, 2016. Business models for model businesses: Lessons from renewable energy entrepreneurs in developing countries. Energy Policy, 95, pp.336-349.

[5] VW Tam, S Senaratne, KN Le, LY Shen, J Perica and ICS Illankoon, 2017. Life-cycle cost analysis of green-building implementation using timber applications. Journal of Cleaner Production, 147, pp.458-469.

[6] O Pekkarinen and M Ali-Marttila, 2016. Managing Industrial Maintenance – Networked Model. In Proceedings of the 10th World Congress on Engineering Asset Management (WCEAM 2015) (pp. 459-469). Springer, Cham.

[7] LBNL 2007. How to Determine and Verify Operating and Maintenance (O&M) Savings in Federal Energy Savings Performance Contracts. Lawrence Berkeley National Laboratory, Berkeley, California. Available at: http://ateam.lbl.gov/mv/.

[8] N Mohd-Noor, MY Hamid, AA Abdul-Ghani and SN Haron, 2011. Building maintenance budget determination: an exploration study in the Malaysia government practice. Procedia Engineering, 20, pp.435-444.

[9] RMW Horner, MA El-Haram and AK Munns, (1997), "Building Maintenance strategy: a new management approach." Journal Of Quality In Maintenance Engineering, Vol. 3, No. 4, pp 273-280.

[10] C Rothballer, 2014. Strategic Infrastructure: Steps to Operate and Maintain Infrastructure Efficiently and Effectively. In World Economic Forum.

[11] NRS 047-1:2005 (Ed. 3.00) https://store.sabs.co.za/catalog/product/view/_ignore.../nrs-047-1-2005-ed-3-00/ Electricity supply - Quality of service Part 1: Minimum standards.

[12] Maintenance of public infrastructure: how to master the art of taming contradictory forces. 24th infrastructure dialogue, Oct 31, 2013. www.infrastructuredialogue.co.za/.../Report-on-Maintenance-of-public-assets.

[13] TZ Moore, KC Kozak, K Brün and A Ramos-Aparicio, 2007, January. Risk, Reliability, and Failure Mode Analysis. In PSIG Annual Meeting. Pipeline Simulation Interest Group.

[14] NRS 093:2008 Asset Management static1.1.sqspcdn.com/static/f/359676/.../NRS+093+ESLCS+presentation_1.pdf?

[15] MR Hodkiewicz, 2015. The development of ISO 55000 series standards. In Engineering Asset Management-Systems, Professional Practices and Certification (pp. 427-438). Springer, Cham.

[16] Municipal Services Benchmarking: Electricity/Energy – Status Quo Assessment 2016/2017 [SALGA].

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The role of South African municipalities in renewable energy: Review of business models

by Aurelie Ferry, Nhlanhla Ngidi and Lungile Manzini, SALGA

This paper was written in cooperation with colleagues from the SAGEN programme of GIZ and SALGA. The pace of change is accelerating in the energy sector. A multitude of factors such as energy supply challenges and increasing electricity prices, associated with decreasing technology costs and increasing product quality, combined with growing concerns for environmental impacts and weakened local and international economies are resulting in a decrease in electricity sales.

The decrease in electricity demand can be attributed to a number of responses by customers. These responses are applicable to various customer types (industrial, commercial and residential) and customers are not limited to one approach. Customers can reduce their electricity consumption through the use of energy efficiency technologies, through more energy efficient behaviours or by suppressing some of their needs due to limited affordability. Electricity theft and non-payment might be another avenue explored by customers, residential and business alike, which lead to an increase in non-technical losses. There is also an increase in customers using renewable energy technologies, with a specific emphasis on the self-generation of electricity through renewable technologies such as solar photovoltaic systems (this is also often called small scale embedded generation). Few customers are also contemplating moving off the grid, which would be the worst case for the electricity distribution industry.

As a result of all these trends and responses, the sales of electricity in municipalities and of Eskom are flat or decreasing. This in turn reduces the ability for municipalities to cross-subsidise electricity tariffs to the poor as well as to raise surpluses for other non-trading services, ensuring sustainable provision of services to all residents. It is worth noting that the decrease in electricity sales takes place while the GDP grows, albeit at a slow rate. This demonstrates that the energy intensity of the South African economy is decreasing slowly and that the decoupling of energy consumption and economic growth is becoming apparent.

The continuous electricity tariff increases over the past years have only exacerbated these trends, providing greater incentives for customers to either find ways of not having to pay for their electricity or to reduce their electricity consumption through energy efficiency and renewable energy systems, sometimes even both. This is illustrated in the graphical representations (Figs. 5 and 6).

At the same time, through these trends and the deployment of innovative technologies and approaches, many opportunities are created for municipalities to provide affordable, modern, safe and environmentally-friendly services to their residents. Instead of continuously increasing electricity tariffs, the electricity industry could explore other mechanisms such as:

- Ensuring that the electricity tariffs are cost-reflective, in structures and levels, and yet affordable (Eskom and some municipalities have already started on this approach).
- Taking advantage of the opportunities offered by renewable energy, such as solar PV systems.
- Using innovative technology and approaches as well as exploring new business models.

Problem statement

As shown previously, the electricity distribution industry is currently experiencing rapid structural and behavioural changes. Customers are a driving force in these processes, as modern technology enables them to make decisions with regard to their energy service provision. A parallel could be drawn with the current challenges in the traditional taxi industry, where customers now have other transportation options. The current rapid changes in the electricity sector could, to a certain extent, be referred to as an "uberisation" of the electricity industry.

Municipalities are forced to innovate if they are to keep up with their customers and retain their ability to provide services to their residents. Municipalities need to embrace and maximise the benefits of the energy transition.

However, the current policy and legislative framework is still based on the old industry model and limits opportunities in the sector, increasing the risks for municipalities.

Energy sector reforms are urgently needed on many aspects (e.g. business model, policy

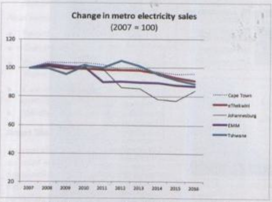

Fig. 1: Change in six metros electricity sales from 2007.

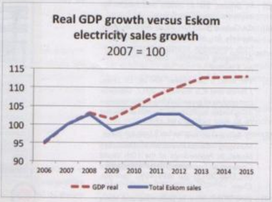

Fig. 2: Change in Eskom electricity sales vs. GDP growth from 2007.

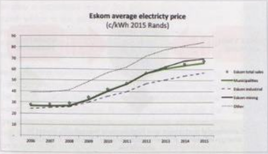

Fig. 3: Change in average tariffs in six metros from 2007.

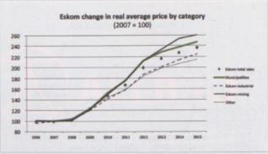

Fig. 4: Change in Eskom real average price by category from 2007.

Roles	The realm of business models
Building generation capacity	On municipal infrastructures
	Stand-alone power plants
Procuring electricity	From customers (SSEG)
	From independent power producers
Playing a facilitation role	Wheeling
	Trading
	Operating a storage facility
	Providing new electricity and energy services

Table 1: Possible categorisation of new business models and roles in renewable energy for municipal electricity utilities (from report referenced in note 3).

framework, grid maintenance practises, adoption of technology, etc.). This will require a country-wide dialogue.

The next section attempts to explore and categorise possible business models for municipal electricity distributors and highlights current practises or barriers.

Possible roles for municipalities in renewable energy

Municipalities, led by the metropolitan municipalities and some intermediary cities, are exploring how they can grasp opportunities from the latest development and decreased costs of renewable energy technology.

To benefit from this development in the sector, municipalities have to change their business models, which was traditionally very simple, involving buying electricity from a bulk supplier for on-selling to captive customers. Business models are understood as maps, frameworks and plans that structure how investments are designed, implemented, managed, and financed. Table 1 presents an overview of these possible roles or business models with renewable energy, which can be categorised in three main categories.

Firstly, municipalities could build their own renewable energy generation capacity. Municipalities used to own and manage electricity generation in the past and could now do so again, specifically since renewable energy presents itself to distributed generation.

Secondly, municipalities could try to diversify their energy mix by buying renewable electricity from a range of producers instead of only from one supplier, as is mainly the case at the moment.

Lastly, municipalities could explore using renewable energy to provide a range of new services to their customers or play a facilitation role in the sector, using their main asset which is the existing electricity grid. The current paper focusses mainly on electricity-based solutions, but municipality could also explore how to provide other energy services such as gas reticulation.

The following sections will explore these three categories in more detail.

Building generation capacity

One of the first business models on renewable energy which could be explored by municipalities is to build their own generation plants. Such installations can have numerous benefits for municipalities: they can lead to job creation and enhanced economic development at the local level. Municipal renewable energy generation plants can also assist municipalities in providing greener services and reducing the municipal climate footprint by reducing greenhouse gas emissions. This is of particular importance to municipalities taking part in international climate change commitment programmes. Municipal renewable energy generation capacity can also assist municipalities with fixed or controllable electricity prices for a number of years – up to 25 years for solar PV for example. For technologies with prices that are reaching grid parity, such installations could be used to strengthen the capacity of municipalities to provide electricity at subsidised tariffs to low income households (Vermeulen P, 2017).

Lastly, when installed on municipal infrastructure, such an installation could increase the efficiency of such installations and provide added co-benefits to the municipality. For example, landfill gas-to-electricity in municipal landfill sites can help reduce air pollution around landfills, or biogas-to -energy in municipal waste water treatment plants can help improve sludge management processes and reduce sludge volumes. These are non-negligible benefits for municipalities, besides simply electricity generation, which do participate in service delivery efforts.

To date, there are a number of existing municipal-owned electricity generation systems using renewable energy. These are mostly small projects for own use within the municipality (municipal buildings, water works) through solar PV systems or waste-to-energy options.

Exploring new business models, municipalities could also investigate installing stand-alone renewable energy plants, on municipal land for example. In most cases, and depending on the Electricity Regulation Act amendment, these plants could require an electricity generation licence. The processes to obtain an electricity generation licence are unclear at the moment (see next section).

An option for municipalities to look at the benefits of such installations is to compare the Levelised Cost of Electricity (LCOE) of such installations with current and forecasted costs of electricity from other suppliers. A methodology still has to be developed to take into account the local added benefits, as previously discussed.

Procuring electricity

Another option currently explored by municipalities is to buy electricity from electricity producers in parallel to the current Eskom supply.

Once again, this could have a number of benefits for municipalities, including and not limited to job creation and local economic development, greener services and greenhouse gas emission reduction, price and supply diversification with increased control.

On the one hand, municipalities could buy electricity from external power producers, following applicable procurement processes before entering into Power Purchase

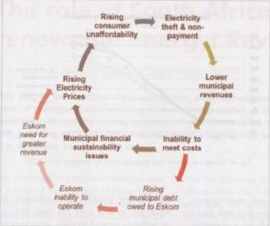

Fig. 5: Theft and non-payment, the vicious cycle, challenging payment capacity of poor households.

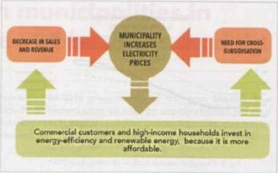

Fig. 6: The "death spiral" (impact of energy efficiency and renewable energy), pushing wealthy customers off the grid.

Province/number of municipalities	Allowing SSEG installations	With official application system	With SSEG tariffs
Eastern Cape	2	2	1
Free State	1	1	1
Gauteng	4	3	2
KwaZulu-Natal	1	1	1
Limpopo	2	0	0
Mpumalanga	1	0	0
Northern Cape	2	1	0
North West	0	0	0
Western Cape	18	15	13
Total (draft Oct 2017)	**31**	**23**	**18**
Percentages of licensees (total: ±165)	19%	14%	11%

Table 2: Uptake of SSEG processes in municipalities (update October 2017 – not final). The data is compiled by SALGA with assistance from GIZ, GreenCape and AMEU.

Agreements. However, in all likelihood, such a power plant would also require a generation licence and as previously mentioned these processes are somewhat complex. This paper does not aim to discuss the current regulatory situation in more detail, as information is available in documents referred to in annexures and in the media. It could however be interesting to mention that during a strategic meeting between SALGA and the Department of Energy, the department indicated the possibility to initiate discussions about the role for municipalities in the implementation of the Integrated Resource Plan (once published).

On the other hand, it is currently an option for municipalities to buy electricity from their own customers through small scale embedded generation (SSEG) programmes. SSEG refers to power generation installations which are located on residential, commercial or industrial sites where electricity is also consumed.

Despite the current legislative uncertainty as well as the absence of published regulations and rules on the topic, but in accordance with communication between Nersa and SALGA and in response to an irresistible push by their customers and to the increased number of unofficial and un-registered installations, municipalities are developing their small scale embedded generation programmes. The aim is to allow their customers to install high quality installations on their premises, which uphold safety and power quality standards. Indeed, SSEG installations provide opportunities and risks for municipalities and need to be managed properly. SALGA's objective is to facilitate the adoption of small scale embedded generation in a way that preserves the financial and technical integrity of municipal distribution systems.

The City of Cape Town and Nelson Mandela Bay Metropolitan Municipality initiated work on SSEG as early as 2008, when a couple of very innovative customers decided to explore options to self-generate electricity. To date, much progress has been made and municipalities are modifying their processes to safely allow their customers to generate electricity and feed back their excess electricity into the municipal grid.

As per available information, about 30 municipalities are allowing customers to connect generation installations to the distribution grid, while 18 municipalities have approved SSEG tariffs. Table 2 contains the temporary results per province and nationally.

Municipalities in the Western Cape have made the most progress to date on the adoption of SSEG processes. Indeed, GreenCape provided assistance to municipalities in the province. Based on the work done by GreenCape, AMEU set up a working group comprising officials from the eight metros, to develop a set of documents which can be used by any municipality. The AMEU SALGA SSEG Resource Pack thus provides templates for municipalities to establish sound SSEG permitting procedures.

Fig. 7 and 8 show how municipalities have adopted SSEG processes since 2016. Before 2016, only the City of Cape Town and Nelson Mandela Bay were known to have SSEG processes and pilot tariffs in place. It is interesting to note that the numbers of municipalities with SSEG processes and tariffs steadily increases over time, now reaching well beyond the metropolitan municipalities. It is expected that it should keep increasing as several municipalities reported being in the process of preparing their application documents, policies, by-laws and tariffs (Fig. 7).

Playing a facilitation role

This third category of business models, titled "playing a facilitation role" is broad and integrates several different options. As previously indicated, municipalities could explore using renewable energy to provide a range of new services to their customers or play a facilitation role in the sector, using their main asset which is the existing electricity grid. The current paper focusses mainly on electricity-based solutions, but municipalities could also explore how to provide other energy services such as gas reticulation.

In a wheeling framework, municipalities would be able to transport electricity from a generator to a consumer, using the existing electricity grid. In such a scheme, the consumer would have a direct Power Purchase Agreement with the generator. This is a new role for municipalities, which would require a proper tariffing for the services. These fees should be equal to the cost of use of the network, ideally based on detailed cost of supply studies.

Operating an electricity storage facility could also have many benefits for electricity distributors. It is however a very new prospect which opportunities and successes would depend on the price of battery storage going forward. Studies are being initiated in South Africa to explore these opportunities.

Other new electricity and energy services could be provided by municipalities. Municipalities could for instance use renewable energy and other technologies to increase energy access and reduce energy poverty. New technologies and renewable energy in particular offer opportunities for municipalities to develop energy household packages, instead of a one size fits all solution through the electricity grid. Indeed, the provision of electricity through the grid is proving very expensive to the municipal operator on top of being unaffordable to the user in many cases. The use of technologies such as solar photovoltaic systems, gas or mini grids could provide safe, affordable and modern energy to the customers, while also benefiting the municipality through a decrease cost of service, although this needs to be explored in more detail and on a case by case basis. Several pilot projects are on-going and the results of these projects will provide very useful data to possibly explore new opportunities in terms of increasing access to energy for all.

Municipalities could also facilitate and/or provide energy efficiency services to their customers. These services could include energy audits or the design and implementation of energy savings opportunities through direct assistance or on-bill financing with the services being provided by Energy Services Companies (ESCo). In a similar manner, municipalities could also install and maintain energy systems, such as smart metering systems, rooftop solar PV systems or solar water heaters against a service fee. These approaches are very new and would require new skills and resources in municipal electricity departments. The regulatory framework linked to the provision of such services would have to be analysed. Such options would however open new doors and provide new revenue options for municipalities, so as to ensure the sustainable delivery of services in the future.

Recommendations and conclusion

The different studies referenced in this paper, as well as further engagements by SALGA with a number of municipalities and a range of other stakeholders in the sector, resulted in numerous recommendations made to ensure that municipalities benefit from the current changes taking place in the sector. This section aims to highlight some of these recommendations as a proposed way forward for the sector.

Firstly, the finalisation of SSEG policy, regulations and related standards is urgently needed and should be prioritised by all the relevant stakeholders. This is the number one

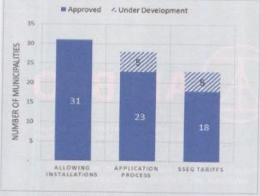

Fig. 7: Uptake of SSEG processes in municipalities (update October 2017 – not final).

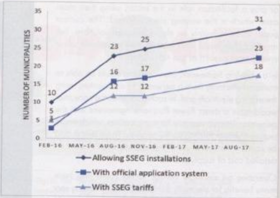

Fig. 8: Uptake of SSEG processes in municipalities since February 2016 (update October 2017 – not final).

Roles	The realm of business models
Playing a facilitation role	Wheeling
	Trading
	Operating a storage facility
	Providing new electricity and energy services

Table 3: Extract of Table 1 – focussing on the third category of business models (from report referenced in note 3, modified by author).

recommendation in all studies and forums. It is understood that progress has been made and all stakeholders are now eagerly awaiting the gazetting of the amendment of the Electricity Regulation Act, which would provide clarity on the licensing exemptions.

The studies, as well as previous AMEU conferences encourage municipalities to embark on experimenting with some of the business models. Municipalities have already initiated some approaches and pilot projects as was shown in this paper. These initiatives will provide information and hands-on experience to unpack each business model with the objective of clarifying the regulatory frameworks and other possible barriers. This approach will be key in ensuring a smooth transition of the energy sector.

To ensure optimal transition and the sustainability of municipalities, new skills and competences will be needed at the local level, as well as for all stakeholders working closely with municipalities in the sector. These new skills can be broadly grouped in three categories:

- *Data:* it is key for municipalities to have a better understanding of the costs related to the distribution business as well as of customer's consumption levels and patterns. This is needed to determine pricing and revenue impacts (e.g. time of use, fixed charges, subsidies, etc.)
- *Technology:* It is also crucial for municipalities to keep abreast of technology development and to understand the potential impact of these developments in the electricity distribution industry. In particular, all development related to the electricity grid will have to be carefully monitored, as the grid is the main municipal asset, which will form the central component of future business models. Current technology developments to closely monitor include meters, customers and demand management systems, rooftop PV systems, as well as electric vehicles and storage, which are bound to result in even greater impacts in the electricity industry going forward.
- *Financial:* financial and modelling capacities will be needed to refine and improve forecasting, budgeting and investment models.

These new sets of skills will enable municipalities to be more involved and proactive in local energy planning and will ensure that adequate tariffs are put in place. These are key factors for a successful energy transition.

In parallel, greater consideration at the national level should be given to the role of municipalities in electricity planning. A bottom-up energy planning process, with necessary technical assistance from national level, should be put in place to ensure adequate integrated energy planning.

Further engagement with the whole electricity industry is needed to ensure a smooth and just transition of the South African energy sector. In particular, the role of municipalities in the electricity supply industry as well as the funding models of South Africa's municipalities will need to be analysed.

The energy transition will require policy dialogue with all actors in the sector. The National Executive Committee at SALGA has resolved to convene a Leadership Energy Summit in this current financial year, in partnership with key stakeholders, where the sector shall reflect on all these changes and transformations, in order to co-create a new energy future for our cities and for South Africa.

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The role of SA municipalities in renewable energy, a review of business models, discussion paper, by Gaylor Montmasson-Clair (TIPS), Karin Kritzinger (CRSES), Louise Scholtz and Manisha Gulati (WWF), commissioned by the South African German Energy Partnership and financed by the German Federal Ministry for Economic Affairs and Energy: http://cityenergy.org.za/uploads/resource_429.pdf

References

[1] Understanding Electricity Demand Patterns in South Africa's cities: http://cityenergy.org.za/uploads/resource_348.pdf

[2] Understanding recent changes in the electricity supply industry with particular reference to new energy and South Africa's cities: http://cityenergy.org.za/uploads/resource_349.pdf

[3] Implications of electricity demand and supply dynamics for South Africa's cities: http://cityenergy.org.za/uploads/resource_350.pdf

[4] Critical issues facing South African cities with respect to electricity: http://cityenergy.org.za/getfile.php?id=363&category=0

[5] SALGA Electricity and Energy Councillor Induction Programme

[6] SALGA Draft Energy Strategy

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Smart grid security perspectives

by Emil Gurevitch, Networked Energy Services

This paper provides smart grid security perspectives from a security expert involved in both attacking and defending these types of systems in practice. It is formatted as an interview, with questions and answers. The topics include smart grid threats, defensive approaches, and security certification perspectives.

Security is getting a lot of attention in all sorts of industries. For utilities, what are the main types of threats they face related to smart meter systems (AMI), and the smart grid in general?

There are three sets of threats that need to be addressed. There is the set of "old school" threats of fraud, theft and safety, which have long been a top concern for utilities. There is a newer and growing set of regulatory threats around non-compliance, such as the General Data Protection Regulation in Europe. Finally, there are the threats associated with the adoption, use and increasing reliance on information technology, such as cyberattacks that can prevent a utility from delivering its services. Some of these threats are similar to those of a traditional IT infrastructure, but their priorities and threat model usually differ significantly. For example, utilities use AMIs and smart grids to store, distribute, and manage energy using information technology. Therefore, they share many of the same assets and corresponding threats as other entities relying on information technology systems.

There are three main types of threats I spend a lot of time thinking about while working on providing a safe and resilient platform for smart grids.

- Threats that disrupt or prevent utilities from delivering energy. Most of us rely on the availability of electricity to power heating systems, hospitals, communication systems, transportation systems, etc. Outages can have severe and even fatal consequences for us and our businesses. There are many threats that can result in outages; from nation-sponsored cyberattacks to software malfunction, operational mistakes and natural disasters.
- Threats originating from criminal organisations that monetise from a utility's lack of security. Over the past years, we have seen a rapid increase in malware samples and attacks specifically targeting utilities managing AMIs and smart grids. "Smart" almost always means "vulnerable" which in turn means opportunity for cybercriminals. A common, and unfortunately effective, tactic is to demand a ransom in exchange for not damaging a utility's infiltrated systems and/or reputation.
- Threats that may compromise our privacy as utility customers. Utilities are responsible for handling and storing private information. This makes data leaks and unauthorised accesses to this data two of the main threats to privacy.

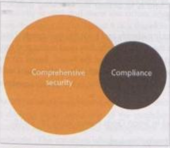

Fig. 1: Key considerations of a security system.

Of course, these are only part of the threat landscape that needs to be specifically mapped out by experts when conducting risk assessments for the specific grid at hand.

AMI and the smart grid is an evolution that continues to change within the industry, how has security and protection evolved over time, and what are the expected changes that we will see in the future?

Before AMIs and smart girds, the industry relied on physical security measures and obscurity to protect the power grid. Fences, door locks, guards, video surveillance, and the obscurity of physically-isolated proprietary control systems were often enough to manage the threats utilities were facing. In addition, incident response procedures were often well-established and fairly comprehensive.

The introduction of AMIs and smart grids, and thus information technology, changed everything and necessitated a new industry expertise: information security. However, although industry embraced the many operational and financial promises of AMIs and smart grids, information security expertise was severely lacking and properly securing these new and advanced systems became an afterthought at best. This resulted in fragile and insecure smart grid deployments developed from non-existent or misguided security recommendations.

We are only now seeing industry and nation-leaders waking up to the "cyber" reality as devastating cyberattacks on utilities are publicly being disclosed. As a result, initiatives to establish nation-wide baseline security requirements and security certifications are in progress. Unfortunately, these initiatives may be too late in some cases and may even foster a compliancy-defined approach to security. We have learned from other industries that this is a harmful approach; an expert-driven risk-based approach to safe and resilient smart grids is the way forward.

Smart grids will continue to increase in complexity, and attacks will continue to increase in both sophistication and frequency. An adaptive and comprehensive approach to security is needed to keep up with this advancement and it starts with expertise, politics, and financial incentives.

How should a utility approach ensure security of its systems?

Utilities need to go beyond compliance, make information security an integral part of their core business and invest in it accordingly, focus not only on protective measures but in detection and incident response as well, conduct independent risk assessments on a regular basis with their technology vendors, and most importantly, obtain as much expert knowledge as possible in order to determine exactly how and precisely where to invest in security.

A misconception that I often hear is the assumption that the internet and the smart grid share identical system characteristics. In reality, smart grids differ greatly from the internet in terms of communication technologies, network reliability, smart meter/server resources, and threat model.

A consequence of applying an internet-biased security mindset to the smart grid can result in degradation of performance forcing utilities to compromise on security in order to meet service-level agreements (SLAs). You must understand the technical differences in order to apply the appropriate security measures. There is no one-size-fits-all when it comes to securing these complex systems.

There are various certifications used by utilities to ensure compliance to various standards and processes. How does certification factor into security solutions and implementations?

One on side, certification provides a minimum baseline of practice and raises the bar for all. Certifications also provide transparency and accountability for security and compliance, and helps utilities demonstrate to regulators and legislators that they are doing their job. If security certification becomes part of regulation, then it also forces utilities to spend money on security. These are all positive and important factors of certification.

On the other side, however, security certifications can discourage utilities to go beyond compliance as there is little financial incentive to do so. Certification processes also have a long-standing reputation for being disruptive, cost ineffective, and providing superficial security assurances. Certification can also discourage new practices and technology adoption because of the need for re-certification. Finally, certifications are slow-moving which is in direct contrast to the fast-changing threat landscape that they hopelessly try to keep up with. That being said, I do believe a regulated security program can be beneficial to the industry if it is able to resolve the issues mentioned before, help hold utilities financially liable for securing the power grids that we all rely on, and to use it as a tool to foster a risk-based and comprehensive approach to security.

What are the key areas needed to ensure a secure system?

Utilities should continuously strive to maintain a safe and resilient system. To do so, three key areas need to be covered: protection, detection, and incident response.

Protection is about trying to prevent security breaches from happening in the first place. Encryption and authentication are two examples of preventative security measures designed to protect the confidentiality and integrity of information, respectively. There is one thing we have learned in the security industry – the highly skilled and focused attackers will always find a way to either break through or entirely circumvent the protective measures. This brings us to detection and incident response.

Detection is about detecting security breaches before, after, or as they are happening. It is important to have measures in place for monitoring both incoming and outgoing events. There are many attacks that go undetected once they have infiltrated the system.

Incident response is about being able to handle breaches of security in a timely and efficient manner. It relies on people, processes, and technology. During a crisis, it is essential to have an action plan in place to regain control of the situation as fast as possible.

You mentioned that "comprehensive security" is the essential approach for utilities. What does this mean to you?

"Comprehensive security" is a loaded term. It means different things to different people. For me, basically, it means that your security goes through a continuous cycle of three stages:

- *Identify:* Pinpointing areas of concern and prioritising them based on risk. This is also known as risk assessment. For a risk assessment to be considered comprehensive, keeping up to date with current threats is crucial.
- *Improve:* Design and implementation of the security measures used to address the identified areas of concern.
- *Evaluate:* Evaluating all of the security measures in practice. This needs to be done internally as well as by an expert third-party ensuring a fresh perspective.

In relation to the previous question, it is worth noting that comprehensive security leads to compliancy.

Some industry experts state that utilities should conduct risk assessments to identify the areas of concern, what is involved in a risk assessment?

The ultimate goal of a risk assessment is to answer the following question: where should we invest in security?

To answers this question, utilities must first identify and prioritise their assets. Next, they need to enumerate all threats to the assets. Finally, they must assess and rank each threat according to the impact and likelihood of the threat. Based on the rankings, a decision can be made as to which risks need to be addressed. This is the classic approach. The hard part, as always, is hidden in the details.

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"Dude, where's my power grid?" – The vulnerability of power grids to cyber attacks

by Jon Longstaff, Omnetric Group, and Rodney Swartz, Siemens

Since the cyberattack on the Ukrainian power grid in December 2015, the theoretical possibility that our power grids are vulnerable to cyberattacks has now become a harsh reality.

With the rapid deployment of smart grid technologies to enhance our networks also comes the challenges that increase our susceptibility to cyberattacks. In this paper we look at some of these challenges and how the use of a common framework can be applied to help address these issues.

Since it began, the energy industry has been developing solutions and systems focused on providing the highest levels of energy availability. These solutions have evolved from electro-mechanical devices to today's digital controls which can enable a higher level of availability in energy supply and improve operational efficiency.

However, our concern here is the impact of these changes on the resilience of a grid when it is faced with cyber-based threats. Before the rollout of digital networks most equipment was connected via private, proprietary networks or direct serial connections, if at all. This, coupled with a focus on reliability, resulted in a set of machine-to-machine protocols which made little provision for cybersecurity. There was an implied set of security controls provided by the underlying communications technology which made it difficult to eavesdrop on them or compromise solutions. The increasing use of commodity digital technology now means that many of those implied controls are being eroded, resulting in the ever-increasing exposure of devices and the protocols they use to communicate.

A common question which is raised when discussing cybersecurity in the energy industry is the motivation of potential attackers. In many industries there are clear financial drivers for attackers but in the energy sector these are limited. However, the important point is that whether there is a clear motive or not, the critical energy infrastructure of a country is vital and there are actors who have the capability to disrupt it. It is therefore essential that operators of these systems are prepared.

The increasing risk to energy systems

As with almost every other sector there is also a drive to make better use of the available facilities by improving the management of networks. The solutions which enable these changes are often referred to as the smart grid and provide opportunities to improve network stability and make better use of grid capacity to avoid issues such as blackouts. A common technique for designing electricity grids is to size the infrastructure to be able to support peak demands with an additional margin in excess of this to ensure continuous operation. Typically these peaks can be many multiples of average loading, meaning that the grid is commonly operating with large amounts of spare capacity.

A more efficient method is to manage down these peaks by shifting load to other points of the daily cycle using techniques such as demand response or energy storage. This allows the grid to cope with higher demand without needing to physically reinforce power infrastructure. Whilst the details of these technologies are beyond the scope of this paper, in essence they are reliant on the use of communications technology to manage pricing or control signals that change demand or shift load. This shifting aims to reduce the peak demands by encouraging consumers to use power at times when there is greater unused capacity in the energy grid.

If these communication channels are disrupted we run the risk of expecting the grid to be able to dynamically manage load when in practice it is unable to do so. In the worst case this would result in cable overheating and resultant physical damage.

This is a very simplistic view of the smart grid but demonstrates how the use of more sophisticated techniques can enable better use of infrastructure but also result in new risks which must in turn be managed.

Vulnerabilities in the energy industry

With the increasing use of common equipment and software infrastructure, the energy industry is subject to many of the same vulnerabilities as other sectors. More specific vulnerabilities are increasingly being disclosed by equipment manufacturers through clearing groups such the ICS-CERT (https://ics-cert.us-cert.gov). This organisation, operated by the US Department of Homeland Security, publishes product specific disclosures for all types of industrial control systems including those used in the energy industry. However it does have limits as it relies on openness from manufacturers who usually only post information about vulnerabilities which have already been patched. Many of these specific vulnerabilities will be familiar to those working with other devices such as network routers where we continue to see privilege escalations, failure to authenticate requests and key management issues.

When considering vulnerabilities, common risk assessment approaches serve well in understanding likely issues. Looking at the energy industry specifically, vulnerabilities are likely to appear in the domains listed below.

- *Physical:* Energy assets are often located in highly centralised facilities which can be well protected but many, and an increasing number, reside in remote locations which makes it difficult to physically protect them. Having vulnerabilities such as BadUSB means that an attacker can breach systems with brief physical access. Similarly, unprotected Ethernet ports are a simple means of entry to a network.
- *Protocols:* Many of the key protocols used in controlling devices were developed with a focus on availability and control, not security. Consequently, there are many examples of vulnerabilities which are intrinsic to the protocols involved. This makes them very difficult to protect against as they can appear as legitimate commands.
- *Cryptographic protection:* Or rather the lack of it. It is increasingly common in internet connected systems to encrypt data using transport layer security (TLS) or an equivalent as a matter of course. In practice many of the devices in the energy industry are simply not capable of performing the necessary processing to support cryptographic protection, even though standards such as IEC 62351 are encouraging this approach. As a result, most network traffic is not protected and can be intercepted by an attacker. This leaves the systems open to man-in-the-middle or replay attacks.

A critical issue with the energy industry is that assets may continue operating for many years, so when looking for likely vulnerabilities we must be looking further than the current, in-vogue vulnerabilities. With legacy devices we must consider vulnerabilities going back many years which are less common in other industries due to corrective actions and natural product retirement.

The Ukrainian power grid attack

The hackers who struck utilities in the Ukraine were highly skilled and planned their assault over many months, first doing reconnaissance to study the networks and steal operator credentials, and then launching a synchronised attack [2].

The attack took part in two phases. In the first stage, the adversaries "weaponised" Microsoft Office documents by embedding malware called BlackEnergy. The attackers delivered a targeted email with a malicious attachment that appeared to come from a trusted source to specific individuals within the organisations. Those individuals were asked to enable macros in order to open the attachments – thus installing the malware on their systems and allowing the attackers to access the company system(s). The adversaries then stole credentials that allowed them to "pivot" into supervisory control and data acquisition (SCADA), and dispatch workstations and servers.

In stage two, the attackers learned how to interact with the utilities' distribution management systems, which monitor and control the distribution of power. The perpetrators also developed malicious firmware to attack serial-to-Ethernet devices at substations. They installed modified KillDisk software, which erases the record of impacted organisation systems and delete logs, and then took control of operator workstations and locked the operators out. To complete the attack, the adversaries used part of the SCADA system to open breakers at several substations, preventing power from flowing across the lines. At least 27 substations were taken offline across three Ukrainian energy companies for several hours, affecting about 225 000 customers.

Improving resilience in the energy industry

We will now consider the topic across five phases of security: identify, protect, detect, respond, and recover. These areas are taken from the NIST Critical Infrastructure Framework [3].

Identify

The first step is to understand what we are trying to protect. In the context of an energy grid this largely consists of the physical control, automation and protection assets where some form of digital/other connection exists. In this section we will show some specific approaches for the energy industry.

Asset management

A specific challenge within the energy industry is the large number of distributed assets and sub-components that form the grid. These assets can be unique and old with limited knowledge available. An approach to address the "identify" process is to undertake an audit of assets while implementing an asset change management process, but this can be problematic. Working and operating in a high voltage substation is hazardous and individuals require specialist training to be present on site. Physical access can then also be limited when dealing with live equipment which may be operating at high voltages or pressures.

Another challenge of working with equipment in this environment is that whilst information may be held about the physical asset, it is often the software elements that are of most interest to the security engineer. In some cases engineers may not even be aware that larger devices can contain well-known operating systems such as Windows or Linux. Therefore the likelihood of them knowing the patch level of a specific software component is very low but yet of crucial interest to a cyber security audit.

Typically when performing such audits on the corporate network, a consultant may initiate a port scan using a tool such as Nmap or a commercial variant. As with many industrial control systems the use of such scanners in the live environment is a risky undertaking. The issue is that many low-power, specialist devices have custom network software, such as their internet protocol (IP) stack. This means that whilst they can correctly interact on expected ports and using expected protocols, unexpected packets of data can in some circumstances cause the device to reset, reboot or freeze. In a live energy environment this could result in serious disruption and even cause safety issues.

We are therefore left with the slow and careful auditing of assets, working closely with power engineers to ensure we understand what needs protecting. When undertaking these audits we must ensure that all are considered and not just the primary energy equipment. Often smaller, secondary assets will still have connectivity and therefore can provide a route for attackers.

Ultimately the security engineer is heavily reliant on good asset management practices, including ongoing maintenance of asset records. Whilst it is difficult, having a comprehensive registry of physical assets, the software that they contain and how they are connected is a critical step in securing an energy grid.

Business environment and governance

Wherever a security engineer is working they are only doing so at request of the operator. This is usually as a result of the organisation which has the responsibility for the operation of the grid either needing to comply with regulation or recognising the risk of not addressing security. Fundamentally the engineer's objective is to reduce the risk exposure of the operator. It is important that this links into the wider security and risk governance but in many organisations this connection is rarely in place. There are many frameworks that can help in this task including the common ISO27001 standard which provides a roadmap for the whole organisation to improve their security posture.

Cybersecurity risk management

There are many assets within the grid which may need attention and we cannot protect them all, nor do we need to. The common approach is to carry out a risk assessment which takes input from the business environment, situational awareness and good security knowledge, and then quantifies the risks faced by the organisation. Some may have already been mitigated but of those remaining we need to select those that our security solution must address.

This approach is no different to applying security in other industries but here we must specifically consider risks inherent in our role of operating critical infrastructure.

- *Commercial risk:* This is the most common area for any business where we consider the risk to the ongoing business performance resulting from a cybersecurity incident.
- *Regulatory risk:* Most energy operators are subject to regulatory supervision which often sets out minimum standards or compliance regimes.
- *Critical infrastructure risk:* We must always recognise the role the energy operator plays in the wider economy and the nature of risks associated with critical infrastructure. Whilst regulation may state a minimum standard, this will generally lag behind the real-world risk by several years. In practice, organisations are a target and there are actors who see the energy industry as a means for advancing various political and economic agendas. Our mantra must be to manage the risk and not the regulation, as the threat landscape will inevitably develop faster than the regulation. Additionally, some operators of critical infrastructure do see it as their social responsibility to protect the grid appropriately.

There are many good sources of cyber security risk assessments which can be applied in conjunction with specific industry knowledge. Using experienced personnel who are familiar with this type of material and how it is applied to the energy industry is essential when undertaking this type of activity.

Similarly we must also be mindful of the privacy requirements as consumers become a more integral part of the grid via topics such as smart metering.

Protect

Now that we have identified the physical and digital assets we wish to include and the risks are understood, our next task is to select appropriate and proportionate strategies to protect them. Many of these strategies will be familiar to security engineers working in other fields but as ever we must be aware of the constraints we work within. A general belief is that security controls should be passive in order to minimise the risk of inadvertently affecting energy supply. Application of more active controls, such as a firewall blocking unauthorised network traffic, must be introduced carefully to ensure that no disruption is caused. We also need to be mindful that we don't prevent authorised users from accessing assets when needed. We cannot risk a field engineer who is attempting to restore power following of a storm being prevented from doing so due to a cyber security protection mechanism.

So within the energy grid we generally opt for intrusion detection rather than intrusion protection, especially if this could risk an automated response which disables devices. This should not, however, prevent us from taking steps to harden networks and devices so that we can reduce the attack surface and make life more difficult for the would-be attacker. Simple techniques such as network segmentation can impede the ability of an attacker to move around the network and so reduce the damage they can cause.

Operators should also consider other strategies such as training, policies, procedures and maintenance.

Protecting the network

Following the completion of the "identify" step we should have a good understanding of the network topology. We can therefore select key points to apply network controls, such as implementing a firewall at the connection between a wide area network and a substation. Ideally this approach would be extended into all the sites allowing the segmentation of networks as described in standards such as IEC 61850. However, the large numbers of locations can limit this due to cost constraints for all but the largest and most critical. Next generation firewalls can provide protection here by limiting traffic to known, expected protocols in addition to the normal approach of ports and addresses. Use of these techniques together can enable application white-listing where we permit known applications but prevent unknown ones from operating. Use of white-listing techniques provides a real-world solution that brings significant benefits in that it supports our critical applications whilst limiting accidental or deliberate misuse.

The most advanced solutions can also start to understand the tolerances that specific devices should expect and detect or prevent instructions which could damage equipment or cause a safety risk. However, this requires a deep knowledge of the protocols and system operation with the risk that this knowledge will not be maintained and the rules quickly become out of date.

We can also consider preventing unnecessary network traffic in line with our policies (see the "detect" step below) which helps in our monitoring of the network. The common solutions for intrusion detection can also assist us.

Protecting the assets

One of the most difficult types of asset to protect are the outdated network connected programmable logic controllers (PLC) and alike, such as power protection devices. Often these devices previously connected via serial port and have had Ethernet cards added over time to enable remote access and monitoring. The security approach has often not evolved to match the increasing threats. The result is simple passwords, simple identity management and little or no encryption. Retrofitting these features is often impossible as the devices cannot be upgraded or simply don't have the processing power required. Access control technologies are available which will control access to devices by automatically changing device passwords. In this model only the access control solution knows the device password and acts as the conduit for access to the device. This technique does provide access control but cannot protect against device credentials being passed in clear text on the local network.

Specific hardening guides should be available from vendors who can provide guidance on the best approach to configuring devices and systems. If these are not available then vendors must be challenged to provide them as they are essential reading. These guides will have been tested to ensure that they do not affect the operation of the device. Device hardening is a critical step in reducing the potential attack surface and one of the most effective approaches available to protect the grid. We should not forget that many security breaches are the result of simple failures such as leaving default passwords unchanged.

A challenging issue with protecting assets is software upgrades. It is common for devices to go without an upgrade for many years leaving them open to well-known vulnerabilities. There is sympathy for the view that "if it isn't broken, then don't fix it". However, many of these devices are broken in the sense that they are insecure even though they may function correctly. Vulnerabilities are common and some vendors are now rightly advocating upgrades by publishing vulnerability disclosures with associated software patches. The challenge is that implementing these patches risks the very service we are trying to protect.

We must also consider the central control systems, such as those running SCADA. These usually run on commercial operating systems and so patching is essential. Some vendors are able to provide specialist upgrade services where experienced teams can execute the upgrade with minimal risk to the live operation.

Earlier we discussed the need for physical protection given that many of our assets are in remote, unmanned locations. Much of security centres around getting the basics right and ensuring that assets are protected against physical access is one such example. Given the ease with which a device can be compromised via a USB port or an unprotected Ethernet connection, it is essential that physical protection is maintained. Related issues such as copper theft mean that the physical security of expensive, critical assets is a key concern.

Detect

It is a common understanding amongst security professionals that there are only two types of organisations; those that have been breached and know it; and those who have been breached and don't know it.

Our underlying techniques for identifying breaches in the energy industry are no different from other situations. The objective is to identify indicators of compromise (IOC) – telltale information which, if spotted, can alert us to malicious activity. The difficulty is that this is not a case of spotting a needle in a haystack; this is about spotting the piece of hay that is not in the quite the correct place.

It must be said that efforts to detect breaches will be compromised if the earlier Identify and Protect phases are not undertaken. There may be a temptation to move directly to the Detect phase, but without a clear understanding of the environment and the assets that need protecting, an effective detection solution is much more difficult.

Network security

One of the most difficult aspects of detecting breaches in many networks is the large volume and diversity of traffic, so that identifying any malicious connections can be almost impossible. This is one case where the professional tasked with protecting our energy grid has an advantage. The nature of our network means that we can and should expect very limited types of traffic. Our security policies should explicitly ban access to external websites and limit traffic to specific protocols and routes. If these policies are rigorously enforced, then we can more easily spot unusual activity. Table 1 provides some examples.

If these policies are not enforced then an attacker will be far harder to identify and we will require much more sophisticated tools. As with any such approach the more complex the solution the greater chance of a false positive and in the energy grid this is one of our biggest risks. Our level of confidence that a breach has occurred must be higher than other fields as any action we take increases the risk of disruption to the service.

We may also be able to protect our network using a deeper understanding of the limited protocols allowed. For example, if we are able to use next generation firewall technologies that can parse control messages and then look for unexpected or invalid values. With very specific rule-sets we can block network traffic which disables protection controls or set unrealistic thresholds for device parameters. Defining these rules is complex and must ensure that all valid control signals are permitted. So whilst the approach can provide protection it does so at a high cost.

Device security

In a similar approach to networks, we can make detection easier by keeping device configuration simple. The removal of unnecessary software components such as media players reduces the likelihood of attack and reduces the number of elements that need monitoring. Simply put, the fewer components involved then the easier detection is.

Anomaly detection

In order to find indicators of compromise (IOC) we can implement a solution which gathers log data and then attempts to identify potential IOCs. There are a number of technologies available to us which are commonly referred to as security information and event management (SIEM) solutions, although other descriptions are used by some vendors.

Policy	Allows us to detect
Strictly controlled outbound internet access.	Malware attempting to connect to command and control server.
Strictly controlled network connectivity between field locations.	An attacker pivoting from one compromised location o another.
Known devices only, e.g. laptops must be registered.	A malicious laptop connected to the network.
Use of known and expected IP ports.	Port scans, attempt to connect to back door.
Password retry limits or logging of access attempts.	Brute force attacks.

Table 1: Examples of security policies.

These solutions follow a five-step process which, as before, we must implement in a way that reflects our environment.

- *Log collection:* The first step is to obtain log data from devices and systems across our network. Our specific challenge is obtaining logs from devices which may not easily relinquish them. The only option here is to work with product vendors to understand how, or even if, devices can publish this information. Ideally they will support the syslog protocol but often it is more difficult than this. A good place to start is the more common IT-related technology, such as network switches where there is a greater chance of log data being accessible.
- *Securing logs:* Log data is only of use to us if we can rely upon it, potentially even in legal proceedings. So it is important that we quickly secure the data, ideally with some cryptographic mechanism so that we can ensure it is not being tampered with. Additionally, we need to move the data to a secure location within our security system. In the energy industry we are often dealing with remote locations with limited bandwidth available to us. Whilst we want to secure our log data we must not impact the operation of critical control systems, so techniques such as bandwidth throttling are important.
- *Log normalisation:* This is the task of converting the device specific data into a normalised form that our SIEM solution can understand. This will again involve the device vendor providing specific information such as log file formats.
- *Log analysis:* This is where we attempt to correlate data from multiple sources, using our understanding of the operation to identify anomalous activity. For the security analyst it is important that they have an understanding of "normal" behaviour so that they are able to assess whether an anomaly is a false positive or really an indicator of compromise. Well defined and enforced policies will improve their detection rates.
- *Reporting:* Finally we must inform operators in the security operations centre of our findings so that they can decide on further actions and how to respond. This must be a well-defined set of protocols which link to the Response approach.

The approach above is the same as for other implementations of log management solutions but requires understanding of the specific devices, risks and operation of energy grid technology. Ideally the security analyst would also be able to cross reference the work patterns of individuals with authorised access to locations. These records, if accessible, provide a key piece of information. Given their requirement as part of the overall safety and compliance regime they should be a trusted source of data. So, for example, if an engineer is seen to access a device via its log, yet they were not shown as working at that site or on that equipment an anomaly may have been found.

Energy network performance detection

It is likely that an adversary attacking the energy network is aiming to cause some form of disruption; either physical or commercial. For energy grids, especially electricity, there will be constant monitoring of network performance and this can support our cybersecurity detection by helping to detect unusual behaviour and recognising this as a potential incident.

From a grid management perspective there are two types of attack – observable and unobservable – which we should consider [4]. Observable attacks are those which would result in detectable changes to the grid operations, such as the deliberate opening of a breaker. These attacks would be immediately detected although they may not be immediately identified as a cyberattack. For these situations the grid control centre should have appropriate training in fault resolution and investigation to be able to consider cybersecurity incidents as a possible cause. It is therefore essential that operations staff are able to understand the nature of possible attacks and their effects so that they can quickly recognise the signs that one might be underway.

A more difficult scenario model is the unobservable attack where the adversary is deliberately manipulating the grid so that the effects are not obvious to operators. There are many different models here but one example is the use of comprised measurement points to "nudge" the control system to a different point of operation without the operator being aware that this is happening. In this case feeding false information into the control system could cause it to make different decisions about the

amount of energy that must be fed into the grid by generators, known as the dispatch process. By gradually feeding incorrect data the overall state of the grid can be changed without detection until it reaches a point of unexpected failure. Alternatively the attacker could cause the grid to operate in a sub-optimal way for an extended period resulting in premature equipment failure or significant cost of unnecessary generation. Detecting this unobservable attack requires a data driven approach where grid operations are monitored to detect anomalous behaviour in the power systems themselves. This is a complex task which requires close collaboration between power engineers and cybersecurity staff.

Respond

There are two key success factors which will determine the effectiveness of a response strategy. The first is to acknowledge the need for a response plan and the second is to prepare that plan thoroughly. This may appear obvious but these two points are commonly missed in cybersecurity. Within the context of the energy industry general incident response plans should already be well established compared to many other industries as they form a key part of normal business operations. The challenge of the security professional is to incorporate cybersecurity into these existing plans.

The basics of incident response planning are common across many situations including the energy grid so we can use common methods and techniques but of course ensuring that we take into account the specific needs of the environment. If an incident occurs the objective will be to either restore power or ensure that power is not interrupted whilst the response to it is undertaken. The cybersecurity response team may not even be involved in the early stages of a major incident unless this has already been identified as a factor. So being able to quickly integrate with an already running incident is essential.

A useful source on incident response is the NIST Guidelines for Smart Grid Cybersecurity which provides a checklist of Incident Response capabilities [5 p. 146].

One point worth mentioning is the role of forensics. As noted above the focus on incident response is to restore the service, in this case the flow of energy to consumers. This can often result in the destruction of evidence which would be critical to understanding how the breach occurred and therefore prevent future incursions. There may also be a need to recover forensic information to support legal proceedings or support wider investigations. Part of response planning should be an agreement with the operations and maintenance team that when equipment is suspected of being involved in a cybersecurity breach, it is removed and quarantined ready for later examination. Many breaches involve techniques such as root kits and firmware changes, especially with devices. This makes incursions difficult to detect and they are likely to be missed completely in the midst of an incident response. Without the correct procedures in place the attacker will remain persistent in the network with continued access and therefore able to easily strike again.

Recover

This is the final step in our approach and the most commonly overlooked. Whilst the immediate incident is now complete, we must still look to ensuring our defences are reviewed and that any short-term solutions we introduced to resolve the situation are replaced or made permanent.

We must also learn from this specific incident and use it as the catalyst for necessary improvements. For example, if one substation was compromised then once we understand how, we must ensure that all other locations are addressed to ensure that they are not vulnerable.

A useful example is recovery from the Heartbleed incident in 2014 where a software component managing secure connectivity was found to leak confidential information. This included security certificates and keys meaning that even when the software had been patched all certificates had to be replaced. The recovery is a long process that is still ongoing. It was found that may devices used in the energy industry also used this same software component and therefore should be patched. We have already discussed the significant challenges this brings but in addition this vulnerability also requires us to replace certificates which is a second maintenance activity.

In an asset intensive industry such as energy, maintenance schedules will be drawn up months or years in advance due to the logistical and operational complexities. Taking a lesson from traditional IT management, an approach would be to ensure that a slot is reserved in these schedules for cybersecurity, even when the specific activity required is not yet defined.

Conclusion

The energy grid is one of the most critical pieces of infrastructure given the place it holds in our world. The increasing use of digital technologies is essential for the successful operation of the grid but brings with it increased risk. By taking lessons learned from other industries it is possible to improve the resilience of the energy grid to attacks. Whilst it is very difficult to prevent an incursion by a determined attacker, it is possible to limit the damage caused and protect the core service of delivering energy.

Acknowledgment

This paper is an extract from the original paper "Cyber security in the energy industry", authored by Jon Longstaff, that was first published by The Institution of Engineering and Technology in their reference library on 15 May 2015 [1]. It is with his kind permission that it is used and adapted.

References

[1] Jon Longstaff. Cyber security in the energy industry. http://digital-library.theiet.org/content/reference/10.1049/etr.2014.0036

[2] Brian Harrell. Why the Ukraine power grid attacks should raise alarm. www.csoonline.com/article/3177209/security/why-the-ukraine-power-grid-attacks-should-raise-alarm.html

[3] NIST. Cyber Security Framework. www.nist.gov/cyberframework/.

[4] Long Tong. Dynamic data attacks on real-time power system operations. tcipg.org/events/seminars/dynamic-data-attacks-real-time-power-system-operations.

[5] NIST. Guidelines for Smart Grid Cyber Security. http://nvlpubs.nist.gov/nistpubs/ir/2014/NIST.IR.7628r1.pdf

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Cybersecurity for critical infrastructure: Legislation and regulation

by Cobus Pool, Proconics

South Africa has been experiencing an upsurge in cybercrime and the cost to the economy has grown by almost 700% from R5,8-billion in 2014 to R35-billion in 2015 [1]. Although the cost of cybercrime as a percentage of GDP is relatively small when compared to other developed countries, we are still reported as being the third most active country in the world when considering the amount of cybercrime [2].

As a general guideline about 0,5% – 2% of all cybercrime and cyber incidents are related to industrial installations. Exact numbers are difficult to quantify due to inconsistencies in reporting.

The European Union Agency for Network and Information Security (ENISA) in a 2015 threat landscape report [3] identified smart grids as one of the installations that is particularly vulnerable to "normal" ICT malware. In a follow up report in 2016, specific malware trends were highlighted as shown in Fig. 1 [4]. It highlights the critical importance of securing industrial systems.

The aim of this paper is to consider the legislative and regulatory frameworks that are in place as well as being changed/considered for implementation. In addition, guidance will be provided on considerations during and post implementation of a cybersecurity management system (CSMS).

Top Threats 2015	Assessed Trends 2015	Top Threats 2016	Assessed Trends 2016	Change in ranking
1. Malware	Increasing	1. Malware	Increasing	Same
2. Web based attacks	Increasing	2. Web based attacks	Increasing	Same
3. Web application attacks	Increasing	3. Web application attacks	Increasing	Same
4. Botnets	Declining	4. Denial of service	Increasing	Going up
5. Denial of service	Increasing	5. Botnets	Increasing	Going down
6. Physical damage/theft/loss	Stable	6. Phishing	Stable	Going up
7. Insider threat (malicious, accidental)	Increasing	7. Spam	Declining	Going up
8. Phishing	Stable	8. Ransomware	Stable	Going up
9. Spam	Declining	9. Insider threat (malicious, accidental)	Stable	Going down
10. Exploit kits	Increasing	10. Physical manipulation/damage/theft/loss	Increasing	Going down
11. Data breaches	Stable	11. Exploit kits	Increasing	Going down
12. Identity theft	Stable	12. Data breaches	Increasing	Going down
13. Information leakage	Increasing	13. Identity theft	Declining	Going down
14. Ransomware	Increasing	14. Information leakage	Increasing	Going down
15. Cyber espionage	Increasing	15. Cyber espionage	Declining	Same

Legend: Trends: Declining, Stable, Increasing
Ranking: Going up, Same, Going down

Fig. 1: Cybersecurity trends from 2015 to 2016.

Legislative

Although it is lagging behind, the South African legal framework has come a long way. To understand how the framework fits together, it is important that there is an appreciation of the history of the acts and preceding policy documents.

Historic perspective

Fig. 2 shows a brief overview of the timeline for the development of the relevant acts. It should be understood that none of the acts/bills have a specific focus on industrial cybersecurity. The aim is rather to focus on critical information infrastructure, including government, financial and security systems. National key points and other industrial systems are included, but only through indirect reference. This, however, does not relieve one of the responsibility of adhering to the requirements. Some of the important acts and drafts will be briefly discussed below.

Electronics Communications and Transactions Act (ACT) 25 of 2002

This act was first promulgated in 2002 and then last updated in 2013. It provides a fairly comprehensive legal basis for e-commerce, information transfer and cybercrime definition. However, it has however not kept up with the changing environment and will be replaced by the Cybercrimes and Cybersecurity (C&C) bill that is currently before parliament. The most important contribution is in Chapter 13 and specifically in sections 86 & 87 where cybercrimes are defined. Almost the same definition is used in the C&C bill. "Unauthorised access to, interception of or interference with data" does cover a wide range of activities, and carries a jail term of up to five years if convicted.

Draft policy 2010

The draft policy resulted in the establishment of the National Cybersecurity Advisory Council (NCAC) and the Cybersecurity Incident Response Team (CSIRT) which reports to the State Security Agency (SSA) in 2013.

First draft cybercrimes and cybersecurity bill 2015

When published, the draft was met with almost universal criticism and condemnation. It proposed quite draconian measures and severe penalties. The Law Society of South Africa (LSSA) was particularly critical and said: "A disturbing element of the Bill is the apparent absence of the appreciation, which is a feature of all credible cybersecurity frameworks, of establishing a balance between civil liberties and the powers of national security and law enforcement agencies. There is no apparent acknowledgement of the constitutional right of privacy, which has been globally recognised as critically important in legislative frameworks that are being developed to address 21st century issues."

Cybercrimes and cybersecurity bill

After public submissions like that by the LSSA, the bill was extensively rewritten and incorporated the majority of recommendations [6]. The result was the bill as submitted to parliament in February 2017. In its current form the bill should not be confused with the draft bill of 2015. While overall structures and prosecution responsibilities remain the same, requirements for obtaining the information requires more formal processes similar to those for the collection of evidence for investigation and prosecution.

Chapter 2 provides a detailed description of what constitutes a cybercrime, but of special interest is the following:

Aggravated offences

11 (1) (a) Any person who commits an offence referred to in:

(i) section 3(1), 5(1) or 6(1), in respect of; or

(ii) section 7(1), in so far as the passwords, access codes or similar data and devices relate to, a restricted computer system, is guilty of an aggravated offence.

(b) For purposes of paragraph (a), "a restricted computer system" means any data, computer program, computer data storage medium or computer system under the control of or exclusively used by:

(i) any financial institution;

(ii) an organ of state as set out in section 239 of the Constitution of the Republic of South Africa, 1996, including a court; or

(iii) a critical information infrastructure as contemplated in section 57(2).

(2) Any person who commits an offence referred to in section 5(1), 6(1) or 10, which

(a) endangers the life or violates the physical integrity or physical freedom of, or causes bodily injury to, any person, or any number of persons;

(b) causes serious risk to the health or safety of the public or any segment of the public;

(c) causes the destruction of or substantial damage to any property;

(d) causes a serious interference with, or serious disruption of, an essential service, facility or system, or the delivery of any essential service;

(e) causes any major economic loss;

(f) creates a serious public emergency situation; or

(g) prejudices the security, defence, law enforcement or international relations of the Republic, is guilty of an aggravated offence.

(3) A prosecution in terms of subsection (1) or (2) must be authorised in writing by the Director of Public Prosecutions having jurisdiction.

Section 57(2) (c) then specifically mentions causing "a major interference with or disruption

Fig. 2: Legislative timeline.

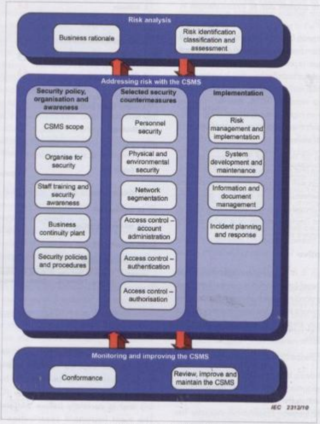

Fig. 3: Overview of CSMS activities.

of an essential service". This will automatically include all national key points. The following responsibilities rest on the owners/operators of critical information infrastructure:

- Apply to have the infrastructure declared critical.
- Comply with directives (at own cost).
- Audits to be performed every 24 months (Section 58).

As owner or operator of such infrastructure, failure to comply is punishable by two years' imprisonment. The act also requires that security be maintained according to "national standards", in this case specifically the SANS standards.

OHS Act (Act no 85 of 1993)

While the C&C bill has not yet been promulgated, it does not relieve one of the duty to implement cybersecurity measures. The Occupational Health and Safety Act contains three specific regulations that touch on cybersecurity for industrial systems. This covers control, safety and smart grid systems including IEDs.

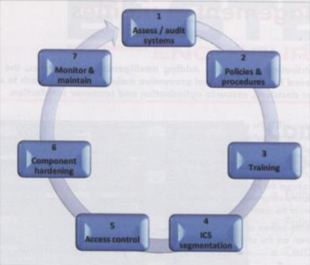

Fig. 4: SANS 62443 implementation process (Proconics).

- General Machine regulations (GMR regulations 3 & 4):
  - Control systems forms part of machine assemblies as it is integral in the operation of the machines.
  - A machine is defined as any device or assembly that converts energy to perform work. This includes switchgear and associated devices.
  - Because the control systems form part of machine assemblies, the requirements around the securing and safe operations of these devices are applicable.
- MHI regulation 6
  - While the MHI requirements are not generally applicable to electricity distribution, it does affect the wider manufacturing community and can have an indirect effect on electrical systems.
  - Owners/operators of MHIs must do risk assessments and mitigation on all new/modified plants. Frequent audits are also required.

Standards

The two associated SANS standards have been accepted as national standards in 2016. It is a full acceptance of the IEC standards. It is important to note that the standards are not prescriptive in how security should be implemented, it only prescribes what aspects should be addressed during implementation. What is important to note is that the applicable devices does not need to be connected to a communication network, it only need to have communication capability.

SANS (IEC) 62443-2-1

The standard can be overwhelming, but the intention is to establish a cybersecurity management system (CSMS). The CSMS is divided into three main activities:

- Analysing risks.
- Addressing the risks.
- Monitoring and improving the CSMS.

Each of these have specific sub-activities with the standard providing the requirements for each. The process is represented graphically in Fig. 3.

The standard uses two important principles as guidance:

- Defence in Depth (DiD) – this includes isolation of functional and logical units.
- Continuous monitoring and improvement.

SATR (IEC) 62443-3-1:2016

This part of the standard is focused on technologies that could be applied during implementation to secure the system(s). It is not required to implement all technologies and in most cases it is also not desirable as it can make the implementation unmaintainable. Note that IEDs are specifically mentioned along with RTUs for electrical systems.

There are six main technology groups:

- Authentication and authorisation – includes password management.
- Filtering/blocking/access control – does not include physical access control, but includes firewalling.
- Encryption and data validation – includes VPNs.
- Management, audit, measurement, monitoring and detection – includes antivirus, IDS and automated software management.
- IACS software – covers the different operating systems.
- Physical security – access control and personnel security.

Because there are so many options, industries generally refer to industry specific guidelines such as the NERC CIP or NIST standards to assist with specific guidelines. When combining the two parts of the standard, most of the problems can be addressed with the process in Fig. 4.

Conclusion

There are extensive changes coming to the legislative framework in South Africa. It is important for the owners/operators of critical infrastructure to be aware of these changes and adhere to the requirements. It is also important to note that while the bill is not yet in place, there are already a number of regulatory requirements in place that must be adhered to.

It is impossible to make your systems 100% secure, but a best effort is required to ensure operational security and continuity.

References

[1] http://ewn.co.za/2016/07/06/Cybercrime-cost-SA-economy-R35-billion-in-2015.

[2] www.sablog.kpmg.co.za/2016/06/cybercrimes-south-africa/.

[3] ENISA ETL 2015.

[4] ENISA ETL 2016.

[5] Comments by the LSSA on the Cybercrimes and Cybersecurity bill – published by the LSSA 30 November 2015.

[6] www.justice.gov.za/legislation/bills/CyberCrimesBill2017.pdf.

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Modern asset management in utilities

by Francisco Arenas and Kai Schlabitz, Schneider Electric

Asset management is a key activity for distribution companies. Adding intelligence and analytics, the asset management approach in utilities can be moved from a traditional preventive maintenance approach to a 21st century digital approach which enables better decisions, resource optimisation and customer satisfaction.

Traditionally the maintenance management of grid assets like transformers and switching devices are characterised by the maintenance strategies run to failure or maintenance in defined cycles. Research shows that only 18% of asset failures are age related so there are many failures which go unnoticed with the traditional asset management strategies. Nowadays more advanced solutions help to optimise asset health awareness.

Information about the existing assets can be found in different software solutions like the geographic information system, the enterprise management system and in advanced distribution management systems. These solutions target the static data management, the geospatial assignment, administration and operation of the assets.

The primary sources of asset health related information are the sensors installed in the field. Typically, there are already existing sensors in the high voltage and partially in medium voltage substations, from where information about the asset health status can be derived. These are for example the electrical measurements like currents and active power where the load the assets have been exposed to, can be measured. Additionally, devices such as temperature sensors in switchgear which monitor the contacts, or online dissolved gas analysers for transformers health monitoring, support the indication of maintenance needs.

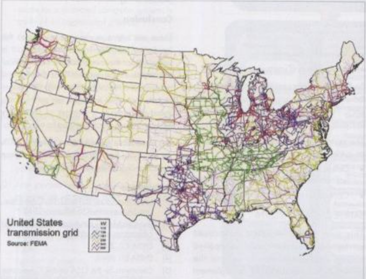

Fig. 1: Geographic information system.

The substation automation system is the next level which should be investigated with respect to the asset management process. Existing and new sensors are connected to the substation automation systems and are available for further processing. However, in the substation necessary information regarding asset management is lost due to limiting the communication to the control centre to the information dedicated to network operation. To analyse the influences on the assets it's important not just to communicate alarms but also the analogue sensor data. For example, transformer oil level or temperatures give more detailed information about the assets. Even more valuable information is the unused potential in the substation automation systems. Modern systems can be activated just by configuration of advanced statistics like operation counters, operation capacity and the sum of switching current.

Fig. 2: Online monitoring.

Fig. 3: Power meter.

The typical communication path from the decentralised substations is the communication to the front-ends of the electrical supervisory control and data acquisition or distribution management systems (DMS). Sometimes further barriers must be overcome to communicate non-operational data, for licence, resource or organisational reasons. For security reasons these systems and networks are usually dedicated to a limited user group in the control centre, responsible for the operation of the network. To enable access to the information for other departments in the company, a web access via a so-called demilitarised zone (DMZ) is often part of the control centre solution.

A more functional way to bridge the operational (OT) and informational (IT) technology is the use of real-time data historians. These historian solutions provide powerful tools to analyse real-time and historian data. The historian solutions can be connected in the OT network, e.g. to the DMS, to gain the relevant time series of data. Even if the DMS is not able to collect all information from the substations, this information can be directly collected from the field using the large portfolio of implemented protocols. Via unidirectional replication mechanisms the OT implementations of the data historians can be mirrored into a central IT implementation which can collect information from very different data sources like other OT systems, for example in power plants.

After crossing this IT/OT-Bridge, the real-time information is finally available for further analysis by the asset management teams and other enterprise users who can leverage from deep insight into the data. Based on this access to information, a real condition-based maintenance approach can be established in a utility.

In addition to the data historians, an even more advanced maintenance approach can be implemented. By using predictive maintenance technologies an early detection of upcoming failures can prevent further damage to assets and enable well-aimed countermeasures. The solution is based on equipment modelling by using advanced pattern recognition. The model is built using historical data to describe how a piece of equipment normally operates. Once the model is created the system continuously monitors behaviour and generates alerts when the operation differs from the historical norm. This provides early warning detection of equipment problems. Upon detection, advanced analysis capabilities

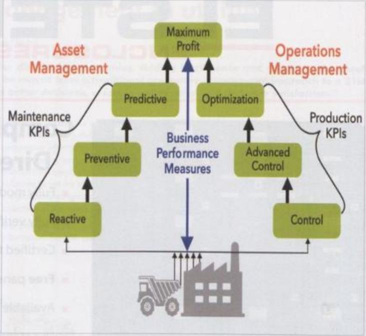

Fig. 4: Asset performance management.

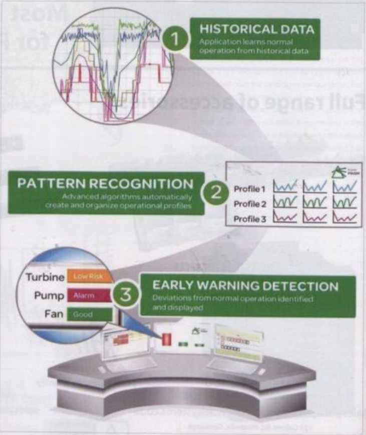

Fig. 5: Predictive asset analytics solution.

identify problems and provide root cause analysis.

The benefits provided by applying a good asset maintenance can be seen in different areas (see Fig. 6).

A good example of this can be seen in the Duvha power plant (6 x 600 MW) where Eskom first installed this system with an investment below US$7-million and savings of US$1-milion within four months. This extraordinary payback of just three months made Eskom implement the system to the entire fleet of generators.

All these steps and levels must be considered to have a better insight into the health status of the grid assets.

But not just the knowledge of the asset health supports the optimisation of the asset management strategy. Also, the longtime commercial optimisation in terms of capital (CAPEX) and operational (OPEX) expenditures can be supported by new tools which are available for utilities. Asset investment optimisation solutions can support the strategic process to define the best maintenance and renewal cycles by providing simulation capacity based on the asset inventory, renewal and maintenance costs to optimise the financial results.

With this new approach, the decisions are taken with a whole-of-company focus, optimising risk, TOTEX and quality of service – all at a company level and providing a clear understanding of medium and long-term impacts of decisions. Models, simulations and integrated planning help departments achieve consensus by understanding the impacts of decisions and optimising for whole- of-company goals, mitigating risks related to over or under-investment.

As an example of the benefits produced by this approach, RTE could achieve:

- 14,5% reduction in OPEX/CAPEX.
- 20% reduction in operational conflicts.

Another example where this new approach has been applied is at EDF Nuclear Generation. An investment programme to maintain and revamp nuclear plants was needed, as the cost of unplanned downtime can amount to up to Euro 1-million per day. The main objectives were the optimisation of power plant maintenance (shutdown) planning, the reduction of conflicts during maintenance operations, improvement of availability factor (KD) at the fleet level and the improvement of robustness of the operational planning against random events. Because of implementing this program, EDF could better identify risk in maintenance plans and optimise power plant shutdown by

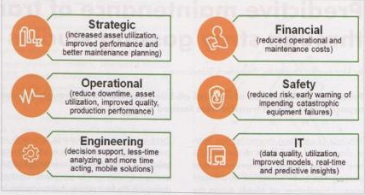

Fig. 6: Benefits of asset maintenance.

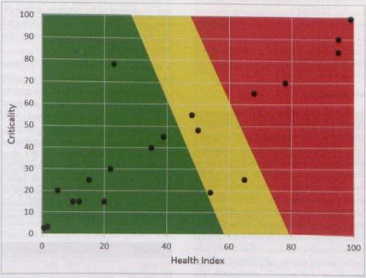

Fig. 7: Health status map.

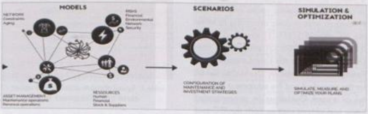

Fig. 8: Asset investment optimisation.

modelling and simulating optimal planning scenarios.

With the adaptation of existing systems, adding further intelligence and solutions which are already available today, the asset management approach in utilities can be moved from a traditional preventive maintenance approach to a 21st century digital approach which enables better decisions, resource optimisation and customer satisfaction.

References

[1] www.arcweb.com/Lists/Posts/Post.aspx?ID=260

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Predictive maintenance of transformers through stray gassing studies

by Matshediso Phashoko, Powertech Transformers

Predictive maintenance of mineral oil-filled transformers through the use of oil condition monitoring is essential especially for critical transformers located in remote areas.

This type of condition monitoring has been in usage since antiquity. In recent years, a new unusual gassing phenomenon, stray gassing has been witnessed in different mineral transformer oil blends across the world. This paper looks at some of the laboratory results of dissolved gas analysis and material compatibility studies using oil samples obtained from virgin oils, oils from transformers believed to have stray gassing activity and transformers known to have classic faults and how stray gassing activity has affected predictive maintenance of transformers.

Introduction

Predictive maintenance of transformers usually involves the monitoring and analysis of gases dissolved in the oil (DGA); oil quality indicators including the dielectric breakdown strength (DS), interfacial tension (IFT), moisture content, dielectric dissipation factor (DDF)/ tan δ, neutralisation number/acidity, colour, sludge content and the concentration of furfural and associated compounds. Gases dissolved in oil and moisture content can be remotely and continuously monitored through the use of online monitors. Other tests require that a manual sample be collected from the transformer and tested in a laboratory. For a normal operating transformer, manual oil sampling may only be required once a year. The interpretation of the absolute values of the dissolved gases and the gas production rates is done according to either the *IEC 60599:2007* [1] standard or the *IEEE C57.104/2008* [2] standard. Other DGA tools include the Duval triangles and Pentagons (developed by Dr. Michel Duval) for the type of oil and the equipment in which the oil is used. Guidelines on recommended limits and alarms exist in both the IEC and IEEE guides. Asset managers usually use these interpretation standards and tools in conjunction and where concerning gassing behaviour is detected, the assessment of oil quality indicators may be employed to further distinguish the fault activity. A deterioration in oil quality is usually accompanied by on-site electrical (e.g. Megger) and detection (e.g. acoustic partial discharge measurements) tests. Depending on the outcomes of these site tests, internal inspections may be conducted and the faulty unit may be sent back to the manufacturing line for repairs.

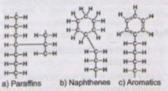

Fig. 1: Molecular structure of mineral oil.

In as early as the mid to late 1970s, there have been reports of unusual gassing activity i.e. stray gassing. Since 1998 [3], this gassing phenomenon has been covered in academic and industry texts and publications. With the proliferation of online DGA monitors, there has been an increase in reports on stray gassing activity. However, this stray gassing has probably always occurred [4]. Stray gassing is the generation of gases, mainly hydrogen, methane and ethane in oils heated at relatively low temperatures (90 to 200°C). Stray gassing activity has been reported for transformers in-service as well as those that had not yet been energised. This decomposition of the oil is in most cases not accompanied by the deterioration of the oil quality. Diagnostic tests and internal inspections performed on transformers with stray gassing activity have yielded inconsequential result.

Gases	90% Typical values (µl/l)
H_2	60 - 150
O_2	-
N_2	-
CH_4	40 - 110
CO	540 - 900
CO_2	5100 - 13 000
C_2H_2	3 - 50
C_2H_4	60 - 280
C_2H_6	50 - 90

Table 1: Typical absolute dissolved gas values.

Gases	90% Typical values (ml/day)
H_2	5
CH_4	2
CO	50
CO_2	200
C_2H_2	0,1
C_2H_4	2
C_2H_6	2

Table 2: Gas production rates in ml/day [1]

In 2013, the *ASTM D7150-13* [5] was published. This is a standardised test methodology for the determination of gassing characteristics of insulating liquids under thermal stress; i.e. stray gassing test. The test samples are aged at 120°C for 164 hrs. The results of the test often do not correlate with in-service DGA results, as also witnessed in similar tests conducted in [3].

Understandably, stray gassing has asset managers worried about the increased risk that such an obscure phenomenon poses to the health of their asset and the implications it has on the validity of their asset insurance cover.

This paper explores case studies involving stray gassing activity, how it is influenced by material compatibility and its effect on condition monitoring.

The role of DGA

Mineral insulating oil used in transformers is made up of hydrocarbon molecules with C-H and C-C bonds, comprising the paraffinic, naphthenic and aromatic chains as illustrated in Fig. 1. A specific oil blend used in a transformer comprises varying quantities of these molecules.

When these molecules are subjected to thermal or electrical stress, the C-H and C-C bonds are served, resulting in the formation of compounds that recombine to form molecular

Parameter	Limit	Reference standard
DS (kV)	≥50	IEC 60156
Water content (ppm)	≤20	IEC 60814
NN (mgKOH/g)	≤0,15	IEC 62021-1
IFT (mN/m)	≥22	ISO 6295
DDF @ 90°C	≤0,20	IEC 60247

Table 3: Typical limits for inhibited oil for inservice power transformers.

hydrogen and other hydrocarbon gases and polymers. The gases dissolve in oil and can be detected by gas chromatography if they are in large quantities and are not depleted through leaky gaskets into the atmosphere. Depending on the composition of the detected gases, fault activity, if present, can be either thermal or electrical. Because certain gases are only formed at specific temperature ranges, the detected gases can be used to determine the temperature range of the fault activity, e.g. the presence of acetylene is associated with arcing, which occurs at temperatures above 800°C.

In dissolved gas analysis and interpretation, the gases frequently used are hydrogen (H_2), oxide gases (carbon monoxide – CO and carbon dioxide – CO_2) as well as hydrocarbon gases including methane (CH_4), ethane (C_2H_6), ethylene (C_2H_4) and acetylene (C_2H_2). The IEC and IEEE both have guidelines on typical dissolved gas values of individual key gases and total combustible gases (TCG) i.e. sum of carbon monoxide gases, hydrogen and hydrocarbon gases.

Table 1 is adapted from [1] and is a guideline on the typical gas concentration values observed in power transformers without a communicating onload tap changer.

In addition to the concentration values, the rate of gas generation (which is usually calculated in millilitres per day) is also critical as it is a better indicator of active fault activity than the concentration values alone.

Table 2 is also adapted from [1] and is a guideline on the typical rates of gas increase per day.

Slightly higher levels of individual or combustible gases may be detected, but if the rates of gas generation are steady, there might not be any fault activity. Conversely, the measured gas concentrations might be lower than the typical values, but the gas generation rates might be higher, indicating possible fault activity. These parameters are used in conjunction with the key gas ratios and further analysis tools such as the Duval triangles and pentagons as applicable for the type of oil and equipment being analysed.

Note that the recommended dissolved gas concentrations and gas generation rates are only a guideline, and it is best to develop recommended values for the specific transformer community in which the transformer under analysis is in. This way, variables such as climatic conditions and loading trends are similar for all transformers and thus similar behaviour can be expected across the equipment age and sub-type, e.g. industrial transformers.

The role of oil quality monitoring

The transformer oil serves as both a coolant and a dielectric insulator. Properties that affect its ability to perform its primary functions are routinely assessed as part of condition monitoring. This paper focuses on the role of the dielectric breakdown strength (DS), moisture/water content, interfacial tension (IFT), dielectric dissipation factor (DDF)/tan δ and the neutralisation number/acidity in condition monitoring.

Dielectric breakdown strength (DS): The DS is a measure of the oil's ability to provide insulation when it is between two electrodes across which a voltage is applied. It is influenced by the moisture/water and particle content of the oil. An oil blend with low moisture and few particles will have a relatively higher DS value.

Moisture/water content: Mineral oil blends typically have a water saturation level of around 55 ppm at ambient temperature. The amount of moisture present in oil affects its dielectric strength. The higher the moisture content, the lower the dielectric breakdown strength.

Interfacial tension (IFT): The IFT is a measure of the strength of the interface between oil and water. It is dependant on the polar groups in the oil and it is mainly negatively affected by polar contaminants. IFT is used as an indicator of the level of contamination in the oil.

Dielectric dissipation factor (DDF)/tan δ: The DDF is a measure of the dielectric losses, which are dissipated as heat energy, in the oil. It depends on the quantity of ionisable and polar molecules in the oil [6], which could increase the temperature rise in-service. The DDF is increased by the presence of contaminants and usually increases at the onset of the oxidation process.

Neutralisation number/acidity: The acidity of the oil is a measure of the quantity of acidic compounds present in the oil. Oil oxidation leads to the formation of carboxylic acids, which increase its acidity. The acidity is also influenced by contaminants such as paints and varnishes. The increasing acidity of oil is usually a precursor to sludge formation.

Table 3 shows recommended values for category A equipment (IEC 60422:2013).

The role of compatibility tests

Whenever a new material or an alternative material is introduced in transformer manufacturing, the standard practice is to test the material for compatibility with the mineral oil. This test is the first line of defence against in-service performance issues. It is not always possible to perform this exercise as some material suppliers alter their production processes without informing transformer OEMs (original equipment manufacturers). The consequence of this is the issue of compatibility only coming to light once the unit has been in-service for some time or when a unit previously in storage is energised. Materials known to have variants that are incompatible with transformer mineral oils are mainly glues (epoxy based), varnishes (for transformer windings) and paints (used to coat transformer walls).

The sample preparation and the analysis of the results of the standard oil

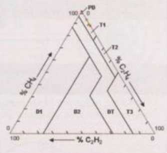

Fig. 2: Duval Triangle 1 results.

Parameter	Allowable aged properties for reference oil
IFT	≥38 (mN/m)
DDF @ 100°C	≤1,1 (%)
DS	≥28 (kV)
NN	≤0,03 mg of KOH change
Colour	≤0,5 change

Table 4: Allowable aged properties for reference oil after aging.

Type	Core-type
Oil preservation system	Sealed conservator
Mineral oil type	Inhibited
Core material	GOES*
Impedance	Standard
Average loading	50%
Oil natural, oil forced cooling – ONAF	100%
Oil natural, air natural cooling – ONAN	60%
Ambient temperature	25°C
Top oil rise (limit)	55
Top oil rise – ONAN	45,2 K
Top oil rise – ONAF	52,7 K
Mean winding rise (limit)	60 K
Measured mean winding rise – ONAN (Max. all windings)	46,9 K
Measured mean winding rise – ONAF (Max. all windings)	56,6 K

Table 5: Details of power transformer exhibiting unusual gassing characteristics. (GOES = Highly permeable grain oriented electrical (silicon) steel.)*

Gases	Concentration (ppm)		Production rate (ml/day)
	19 Jul 13	2 Sep 13	
H_2	198	199	2,17
O_2	155	161	-
N_2	86 656	87 392	-
Gases	**Concentration (ppm)**		**Production rate (ml/day)**
	19 Jul 13	**2 Sep 13**	
CH_4	96	96	0,00
CO	100	99	-2,17
CO_2	157	155	-4,34
C_2H_2	ND	ND	-
C_2H_4	13	13	0,00
C_2H_6	411	421	2,70
TCG*	818	828	127,29

Table 6: Regular DGA results for 2013 (44 days between samples). (As assessed according to [2].)*

Gases	Test sample	DE suggested limits
H_2	1150	590
CH_4	558	120
CO	878	450
CO_2	1470	1580
C_2H_2	0	0
C_2H_4	16	8
C_2H_6	498	120

Table 7: Laboratory stray gassing test results for samples sparged with air zero [8].

Gases	Test sample	DE suggested limits
H_2	636	250
CH_4	683	80
CO	638	115
CO_2	1188	385
C_2H_2	0	0
C_2H_4	14	6
C_2H_6	592	36

Table 8: Laboratory stray gassing test results for samples sparged with nitrogen [8].

compatibility test are done according to the ASTM D3455-02 [7]. Duplicate samples are prepared for testing. Typically, the test material sample is aged in the mineral oil in an oven set to 100°C for 164 hours. After the aging period, the sample is removed from the oil and tests to assess the influence of the test material on the oil as well as the influence of the oil on the test material are conducted. To test how the test material affects the oil, oil quality tests are performed. To test the effect of the oil on the test material, tests related to the usage of the material in transformers are conducted. For example, if the test material is a gasket used to seal gaskets and prevent oil leakage, the tensile strength of the gasket before and after aging in oil would be conducted. Guidelines are documented in the testing reference standards on acceptable test results for the reference oil (oil aged without the test material) samples. The allowable percentage change in the properties of the oil and the test material after being in contact with each other are usually agreed upon by the purchaser and the test material supplier prior to testing. Percentage changes outside these limits render the material incompatible with the oil or warrant further tests.

Worth noting is that the ratio of the test material to the oil and the curing methods used (in the case of glues, varnishes and paints) are usually not representative of the case of real transformers. Typically, the concentration of the test material is higher than it would be in an actual transformer, thus making its influence much more pronounced than in reality.

Table 4 presents the allowable properties for aged reference oil and is adapted from [6].

In recent times, dissolved gas analysis after aging has been performed on the oil as part of the compatibility tests. This analysis is performed to determine the gassing characteristics that the oil exhibits when the test material is introduced. This practice was adopted after reports of stray gassing phenomenon experienced in otherwise healthy transformers. Because this dissolved gas analysis does not form part of the standard compatibility test, the results are only used for informative purposes.

Stray gassing

Until recently, stray gassing tests have only been performed by oil suppliers on oil batches before shipment. With the increase in reports of stray gassing activity in fairly new transformers, (less than five years in-service), transformer OEMs and end-users started performing the test in-house.

Though a standard test methodology for stray gassing exists [5], there are still no clear guidelines on what levels of stray gassing are acceptable and when stray gassing activity should be a concern.

There are two stray gassing test sample preparation methods documented in [5]. This paper focuses on *Method A*. In *Method A*, the oil is filtered through a mixed cellulose ester filter. Duplicate samples of the oil are sparged with air zero (and other duplicate samples with nitrogen) for 30 minutes. The sparging of the oil samples with the two gases is done to simulate the different types of oil preservation systems used for transformers, i.e. free-breathing and in contact with oxygen (air zero) and sealed (nitrogen). Duplicate samples are then placed in a glass syringe, sealed and then aged at 120°C for 164 hours. After the aging period, the samples are removed from the oven, cooled to room temperature and then subjected to dissolved gas analysis.

Test results have shown that oil in contact with oxygen tends to produce higher levels of hydrogen compared to other combustible gases.

Adjusting the aging temperature and duration to simulate in-service conditions has been done. Results of such modified tests can then be used to establish a gassing fingerprint attributed to thermal stress. Establishing a gassing fingerprint for stray gassing activity is especially useful in transformers filled with oils known to produce stray gases. The stray gassing baseline can be used to adjust the gases detected from standard DGA tests in order to distinguish between stray gassing activity and classic transformer faults. This process is covered in [3].

Case studies

In 2013, a customer submitted reports of unusual gassing behaviour exhibited by an in-service autoconnected transformer with a noncommunicating on-load tap changer manufactured in 2004. Table 5 is a summary of the transformer details.

DGA trending started in March 2013. Table 6 shows the results of regular DGA measurement for two samples collected in July and September 2013. The concentration of hydrogen and ethane exceed the typical values of Table 1 substantially. In addition, the daily generation rate for ethane was more than ten times the typical value [1].

According to [2], the transformer is in *Condition 2*, i.e. the transformer is producing greater than normal combustible gas levels, and any individual combustible gas exceeding specified levels should prompt additional investigation. Sampling frequency should be increased to monthly. This was subsequently implemented.

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Gases	Concentration (ppm)		Production rate (ml/day)
	4 Jun 15	27 Nov 15	
H_2	83	111	15,36
O_2	5780	6099	–
N_2	177 645	88 447	–
CH_4	165	177	6,58
CO	162	189	14,81
CO_2	199	215	8,78
C_2H_2	ND	ND	–
C_2H_4	ND	15	8,23
C_2H_6	384	534	82,30
TCG	**794**	**1026**	–

Table 9: Regular DGA Results for 2015 (174 days between samples).

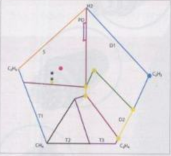

Fig. 3: Duval Pentagon 1 results.

DGA interpretation using the key gas ratios was inconclusive; each ratio showed a different fault.

The Duval triangles for mineral oil (Triangles 1, 4 and 5) were then used to map the possible fault. The results of the interpretation using Triangle 1 are shown in Fig. 2.

Triangle 1 indicated a thermal fault of temperature less than 300°C type for nine of the ten samples. The one sample indicated a PD fault mainly due to the low levels of the detected dissolved ethylene.

Triangle 4 indicated a non-determinable fault for all the samples. *Triangle 3* indicated an overheating fault.

Triangle 5 indicated overheating activity of temperature less than 250°C for all the samples.

On-site tests, including electrical tests, SFRA and diagnostic tests, showed no signs of fault activity. Subsequent internal inspections were also not forthcoming.

An additional sample was collected in September 2013 to be tested for stray gassing. The sample was tested at the Doble Engineering (DE) insulating materials laboratory, as there was no test facility in South Africa at the time that could perform this test. Tables 7 and 8 show the laboratory stray gassing test results for oil samples sparged with air zero and nitrogen respectively. Also shown in these tables are the DE stray gassing criteria limits for individual gases. These limits were developed from samples tested for numerous customers across the world using different oil blends.

The stray gassing assessment is done as follows: If any of the listed gases is more than 10% above the set limit, then the oil is stray gassing. The severity of the stray gassing activity is determined by the magnitude and the number of gases that exceed their limits.

As seen in Tables 7 and 8, the oil is excessively stray gassing in both the oxygen-rich and oxygen-deprived environments. Case studies documented in literature including [3, 4] revealed that the solution favoured by most OEMs and utilities to remove gases due to stray gassing activity was *degassing*, a process by which the gases are reduced to non-detectable levels. Noted in these studies was that the stray gassing activity can plateau on its own at the already established gassing level and that the recurrence of stray gassing activity, albeit at a reduced level, had been observed after transformers had been degassed. The transformer was degassed in 2014 and a new DGA trend was established. The stray gassing activity re-emerged in early 2015.

After the publication of the algorithm for the Duval Pentagons [9], the interpretation of the DGA results was conducted using these new tools. Both indicated stray gassing activity for all ten samples as shown in Fig. 3 (Pentagon 1 results).

The oil quality parameters for the 27 November 2015 sample is presented in Table 10.

Throughout the trending period, the oil quality indicators remained within limits.

In mid-2015, the OEM established a stray gassing test facility in their oil laboratory. To validate the test setup, samples from this transformer and other transformers with gassing activity due to classic faults and stray gassing were sent to Doble Engineering and Eskom Laboratory (EL) in Bloemfontein (a test facility for stray gassing had recently been established). It was expected that the levels of the dissolved gases measured by the three laboratories would vary; but similar gassing characteristics for each sample were expected across the laboratories.

Parameter	Measured	Limit
DS (kV)	80	≥50
Moisture (ppm)	5	≤20
NN (mgKOH/g)	0,02	≤0,15
IFT (mN/m)	41	≥22
DDF @ 90°C	0,00376	≤0,20

Table 10: Oil quality indicators for in-service equipment of category A (IEC 60422:2013).

Gases	Transformer 1	Transformer 2
H_2	1349	404
CH_4	220	19
CO	496	790
CO_2	1404	1637
C_2H_2	ND	ND
C_2H_4	4	11
C_2H_6	172	ND

Table 11: OEM's stray gassing test results [9].

Tables 11 to 13 show the test results obtained by the three laboratories for oil samples sparged with air zero. Presented in Tables 11 to 13 are a comparison of stray gassing test results for oil collected from *Transformer 1*, i.e. the transformer with stray gassing activity, and *Transformer 2*, i.e. a transformer known for partial discharge activity as determined through acoustic measurements and an internal inspection.

The gassing characteristics under thermal stress for oil from *Transformer 1* are similar for all three laboratories, with the exception being that higher carbon monoxide levels were detected at the OEM's laboratory. The results for *Transformer 2* are similar for the OEM and DE laboratories, whereas the Eskom laboratory detected higher ethylene levels.

The regular DGA results of *Transformer 2* before it was repaired showed a combustible gas composition as follows: TCG (356 ppm), hydrogen (244 ppm), methane (23 ppm) and carbon monoxide (89 ppm). The other hydrocarbon gases were non-detectable.

Material compatibility studies were conducted in conjunction with the stray gassing tests. Table 14 presents the DGA results (after standard compatibility aging) of metals used in transformers that passed the oil quality compatibility tests, but have been known to facilitate the generation of combustible gases

Gases	Transformer 1	Transformer 2
H_2	1251	196
CH_4	182	16
CO	216	437
CO_2	532	881
C_2H_2	ND	ND
C_2H_4	4	12
C_2H_6	171	8

Table 12: EL stray gassing test results.

Gases	Transformer 1	Transformer 2
H_2	1347	283
CH_4	191	26
CO	223	579
CO_2	618	839
C_2H_2	ND	ND
C_2H_4	5.1	8.3
C_2H_6	186	2

Table 13: DE stray gassing test results [10].

Gases	RO	GOES	BC	MS
H_2	79	67	73	79
O_2	38 081	21 967	36 894	40 814
N2	99 598	52 709	96 535	104 581
CH_4	2	2	3	3
CO	210	111	215	218
CO_2	1132	858	1149	1207
C_2H_2	0	0	0	0
C_2H_4	0	0	0	0
C_2H_6	0	0	0	0
TCG	291	180	291	300

Table 14: DGA results after aging for compatibility tests – metals.

of high temperatures. The results are for the reference oil (RO), GOES, bare copper (BC) and mild steel (MS). As expected, the composition of the dissolved gases does not match that indicated in Table 9.

A metal oxide paint variant (used as an internal coating in radiators and transformer tanks) that was at the time suspected of being responsible for the excessive gassing was also tested using both inhibited and uninhibited oils.

The DGA results (after standard compatibility aging) presented in Table 15 are for the samples aged in inhibited and uninhibited oils from the same oil supplier. Only carbon monoxide could be detected in the aged reference oil samples; at detected levels of 13 ppm and 30 ppm for the inhibited and uninhibited oil samples respectively.

The results in Table 15 show that the presence of oxidation inhibitors is a large factor in the composition of the gases generated when the oil is in contact with the paint at elevated temperatures.

Conclusions

Unusual gassing behaviour of transformers due to stray gassing is a phenomenon whose mechanisms are not yet fully known. Approaching the problem of excessive gassing through a combination of existing tools such as regular dissolved gas analysis and oil quality monitoring may shed light on whether the activity is detrimental to the oil. Establishing a stray gassing baseline of the oil prior to filling transformers can be used to distinguish between classic faults and gassing due to

Gases	Inhibited oil	Uninhibited oil
H_2	0	611
O_2	186 904	39 494
N_2	566 451	362 707
CH_4	0	139
CO	22	1184
CO_2	592	1768
C_2H_2	0	0
C_2H_4	0	6
C_2H_6	0	71
TCG	22	2011

Table 15: DGA results after aging for compatibility tests - 1 day cured metal oxide paint sample.

this phenomenon. Such a gassing baseline should be incorporated into standards and tools for the assessment of transformer health. A broader study on transformers in the South African network using the Eskom approved oil blends should be conducted to establish local stray gassing limits.

Acknowledgements

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References

[1] ANSI IEEEC57.104/2008, Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

[2] IEC60599:2007, Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis.

[3] Recent Developments In DGA Interpretation-Joint Task Force D1.01/A2.11, CIGRE Brochure N° 296, 2006.

[4] I Höhlein, Unusual Cases of Gassing in Transformers in Service, IEEE Electrical Insulation Magazine, Vol. 22, Issue 1, February 2006.

[5] ASTM D7150-13, Standard Test Method for the Determination of Gassing Characteristics of Insulating Liquids Under Thermal Stress.

[6] Nynas AB, Transformer Oil Handbook, Sweden, 2010, pp. 97.

[7] ASTM D3455-02, Standard Test Method for Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin.

[8] Doble Engineering, Insulating Materials Laboratory Report No 131193, September 2013.

[9] Doble Engineering, Insulating Materials Laboratory Report No 158468, December 20135.

[10] M Duval and L Lamarre, The Duval Pentagon – A New Complementary Tool for the Interpretation of Dissolved Gas Analysis in Transformers, IEEE Electrical Insulation Magazine, Vol. 30, Issue 6, November/December 2014, pp 9-12.

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The embedded solar PV market in South Africa

by Dr. Christopher Haw and Niveshen Govender, SAPVIA

Over the past 24 months South Africa has seen an exponential increase in the number of embedded solar photovoltaic systems, particularly in the commercial and industrial sector. Estimates of annual installed capacity range between 80 to 120 MW p.a. with a total installed capacity of around 300 MW. Unlike the large utility scale program which has procured almost 3 GW of solar of the past five years, this market is not based on government incentives or guarantees, but purely on the economics of cost saving using solar rather than conventional utility supplied electricity.

The dynamics of this market are significant (i) because there are occurring in an area that is inherently difficult to regulate and currently in the absence of clear regulation, (ii) because they signal a further reduction in the demand for electricity sales from, in some cases, already financially constrained utility companies and (iii) because they signify the start of an energy transition to more distributed electricity generation and storage. In this paper we provide the South African Photovoltaic Industry Association's view on the current PV market, the need for clear regulation and the efforts so far that have been carried out to self-regulate the industry in the form of the PV GreenCard.

Lack of regulation

South Africa's Energy Regulation Act stipulates that every electricity generator must obtain a licence from the National Energy Regulator (NERSA) unless they are generating electricity for "own use" purposes. The definition of "own use" can be interpreted differently, with regulators insisting that it would only apply to a user that is entirely disconnected from the national grid and developers and consumers interpreting it as "not feeding anything back onto the grid". In order to receive a generation licence from NERSA there must be an allocation for the applicant's technology in the Integrated Resource Plan (IRP) and the minister must have made a determination that the state wants to procure such technology.

The meter embedded generation technology was not envisaged as a state procured source of energy and therefore, up to now, there has not been any provision created for such technology in the prevailing IRP. This IRP, which is meant to be updated every two years, has been delayed by five years due in part to ongoing lobbying to try and include nuclear energy into the plan, despite independent research indicating that it would not be economically feasible. Further to this, NERSA has released a draft set of guidelines, which are not yet enforceable, envisaging a requirement for embedded generators to obtain licences above 1 MW in size. As a result there is significant uncertainty from different stakeholders as to how to treat these projects from a regulatory perspective. This in turn has resulted in some developers and consumers progressing with unregulated projects of significant size (up to 5 MW) and also has hindered the development of third party financing for PV systems, which has been a major enabler in other markets. From an industry perspective, SAPVIA encourages regulation that:

- Does not arbitrarily restrict larger system installations where they are technically feasible.
- Encourages third party financing of systems.
- Provides municipalities and consumers with clear requirements for quality standards, connection procedures, system information and timeframes to process applications.

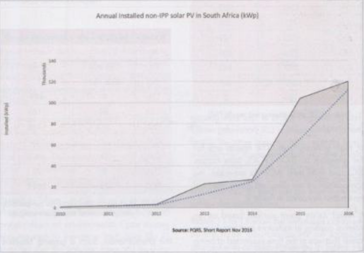

Fig. 1: Estimated market growth in non-IPP projects 2010 – 2016.

Market growth and effect on utility sales

Despite this lack of certainty around regulations, many consumers have taken the view that if their solar generation never exceeds their consumption they are "own users" and as a result a significant number of installations have been concluded, some even larger than 1 MW in size.

Furthermore, many of these installations have been procured by large listed corporates (e.g. Growthpoint Properties, Redefine Properties, Attacq Property Fund, Atterbury Properties). At an average price of R1,00 per kWh and assuming a solar specific yield average of 1650 kWh/kWp, the installed capacity is currently offsetting approximately R420-million per year. With the reduction in PV module price and further increases in utility tariffs, the business case for solar systems such as those already installed is improving; presenting a potentially continued exponential growth in the sector. In a global context it is not unusual for solar markets to grow to rapid rates (see Table 1).

Movement to a new energy paradigm

The trends in South Africa are not unique: China installed 13 GW of solar PV in a single month in 2017; over 10 GW of utility solar projects have applied for grid connections in

Avg. Y.o.Y. growth rate of annual solar PV installations over period shown		
Global	2010 – 2017	20,47%
Americas	2010 – 2017	37,75%
Asia	2010 – 2017	51,37%
MEA	2010 – 2017	92,86%
Germany	2006 – 2012	48%

Table 1: Year on year global growth of annual installed PV capacity in different markets (IHS Market Research 2016; "Annual Report 2015". IEA-PVPS. 13 May 2016. p. 63).

Australia within the last six months and the USA projects distributed solar to reach the cost of electricity transmission by 2020. With solar equal to the transmission costs of electricity, an alternative source would have to generate electricity at zero cost to compete. Battery storage costs are being driven down through economies of scale and the increasing demand for electric vehicles. Electric vehicles will increase the global demand for electricity and with many vehicles parked during the day solar power seems likely to play a significant role in meeting this demand.

The future role of utilities in this context is likely to be vastly different from today. In the business as usual scenario utilities will have to increase prices to cover less revenue at the same operational cost. This will further improve the case to migrate to alternative energy sources and storage, ultimately leading to an unsustainable position for utilities. Regulators will find it difficult to prevent consumers defecting from the grid and those that do will create more pressure on the grid to charge existing customers more.

Grid defection is not the most efficient future for the energy system as a whole. Ideally consumers would want to generate and store as much as they are able to over the time periods that they need their energy. Since demand and renewable energy supply is variable and space dependent there may be cases where there is an over or under supply of electricity. In these cases the network can play a role in connecting one consumer's supply with another's demand. For example, a large single storey warehouse can power a high-rise building in the CBD that has no space for solar. Intelligent networks that are able to use weather and consumption forecasts to optimally operate a network can charge users for using this service. Utility companies or state owned service departments are in a position to play this role.

PV GreenCard: the start of self-regulation

SAPVIA's members have identified the lack of regulation and standards as a potential market risk and have thus developed their own industry standard for ensuring safe and high quality connections. The programme is called the PV GreenCard. Installers are encouraged to register on the PV GreenCard programme by enrolling their personnel in training programmes. Consumers are encouraged to insist that companies they use can present these qualifications in order to ensure that installations are of sufficient quality and meet safety requirements. The programme was launched in June 2017; to date there are 36 installers registered.

Conclusion

Solar PV as an embedded generation source has seen prolific growth over the last 24 months. The business case for solar remains lucrative to consumers, leading to expectations of further exponential market growth. Currently there is a lack of appropriate regulation, giving rise to developers and consumers establishing their own self-regulation policies and interpretations of the existing law. Utilities, by their nature being difficult to transform, are at risk if more attention is not given to what the future energy system is likely to look like and how best to regulate it.

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Miniature substations: What they are really capable of delivering

by Rhett Kelly and Greg Whyte, ACTOM Medium Voltage Switchgear

The latest edition of the South African national standard for miniature substations, SANS 1029 Edition 3, was published in 2010 and has thus been in place for at least six years. Both users and manufacturers have been referencing this standard, but few people in the industry really understand some of the key concepts relating to the on-site capability of miniature substations to deliver their rated maximum power.

SANS 1029 Edition 3 (previously dual numbered as NRS 004) now references SANS (IEC) 62271-202 as the primary normative reference to which miniature substations in South Africa are to be designed and tested. Previous editions of SANS 1029 (and NRS 004) made reference to SANS (IEC) 61330 – but only with respect to the internal arc testing of the miniature substation. In 2007, SANS (IEC) 61330 was withdrawn and replaced by Edition 1 of SANS (IEC) 62271-202 – the international standard for high-voltage/low-voltage prefabricated substations.

SANS 62271-202 provides a clear definition of the rated maximum power of a miniature substation and provides the temperature rise type test requirements applicable to complete miniature substation assemblies. Furthermore, it provides clear guidelines on how to determine the rating of a transformer within an enclosure. However, in most cases, many users and engineers have either not read or not understood exactly what the rating of a mini-substation is, and more importantly, what it is really capable of delivering. The impact and relevance of concepts such as the temperature class of the enclosure, transformer de-rating, load factor, transformer temperature rise limits, solar radiation and average site ambient temperature conditions are poorly understood and applied in the real world.

This paper aims to highlight the common misconceptions in the industry and present the truth behind what miniature substations are really capable of delivering. It would surprise many that the actual output power capability of miniature substations having the same nominal rating (e.g. 500 kVA) supplied by different manufacturers can vary significantly. Power utilities and users would do well to take note of and understand the key issues discussed in order to better understand what they are really purchasing – and the possible financial implications.

References

SANS 780, *Distribution Transformers*

SANS 1029, *Miniature substations for rated a.c. voltages up to and including 24 kV*

SANS 61330, *High-voltage/low-voltage prefabricated substations* [withdrawn and replaced by SANS 62271-202]

SANS 61439-2, *Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies*

SANS 62271-202/IEC 62271-202, *High-voltage switchgear and controlgear – Part 202: High-voltage/low-voltage prefabricated substation*

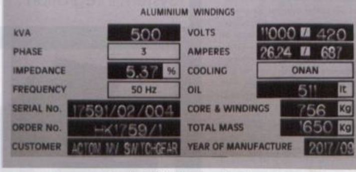
SANS 60076-1, *Power transformers – Part 1: General*

SANS 60076-2, *Power transformers – Part 2: Temperature rise*

SANS 60529, *Degrees of protection provided by enclosures (IP Code)*

Important concepts and definitions

SANS 62271-202 and SANS 60076-2 introduce some important concepts and definitions, including the following:



Example of a 500 kVA transformer nameplate.

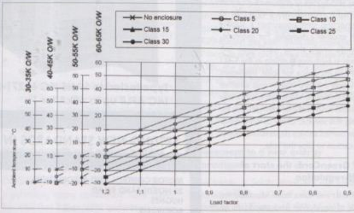


Fig. 1: Oil-filled transformer load factor in an enclosure.

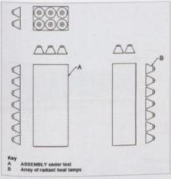


Fig. 2: Proposed arrangement of radiant heat lamps for temperature-rise test with simulated solar radiation.

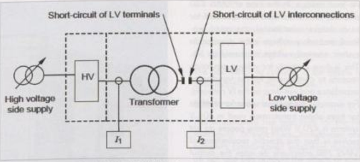


Fig. 3: SANS 62271-202 preferred temperature-rise method.

Prefabricated substation (e.g. miniature substation): type-tested assembly comprising an enclosure containing in general transformers, low-voltage and high-voltage switchgear, connections and auxiliary equipment to supply low-voltage energy from a high-voltage system or vice versa.

Class of enclosure: the difference of temperature rise between the transformer in the enclosure and the same transformer outside the enclosure at normal service conditions.

Rated class of enclosure: The rated class of the enclosure is the class of the enclosure corresponding to the rated maximum power of the prefabricated substation. It is important to note that the transformer rated values (power and losses) correspond to the maximum rated values of the prefabricated (miniature) substation.

The rated class of the enclosure, the transformer temperature rise and the service conditions are used to determine the load factor of the transformer. There are six rated classes of enclosure: classes 5, 10, 15, 20, 25 and 30 corresponding to a maximum value of difference of the temperature rise of the transformer of 5 K, 10 K, 15 K, 20 K, 25 K and 30 K.

IP Code: a coding system to indicate the degrees of protection provided by an enclosure against access to hazardous parts, ingress of solid foreign objects, ingress of water and to give additional information in connection with such protection.

Transformer load factor: per unit value of constant current that can be taken from the transformer at constant rated voltage.

Rated maximum power of the prefabricated substation: The rated maximum power of the prefabricated substation is given by the maximum rated power and the total losses of the transformer (as defined in SANS 60076) for which the substation has been designed. It is critical to note therefore that the rated power of the miniature substation is determined from the transformer nameplate rated power.

Ambient air temperature: temperature, determined under prescribed conditions, of the air surrounding the enclosure of the prefabricated substation.

Yearly average temperature: the calculated yearly average ambient air temperature at the installation site – equal to one-twelfth of the sum of the monthly average temperatures. For air-cooled, oil-immersed transformers, the yearly average temperature should not exceed 20°C.

Location	Yearly average temperature [°C]	Monthly average temperature (hottest month) [°C]	Average of the daily maximum temperatures (hottest month) [°C]	Highest recorded temperature [°C]
SANS 60076-2 limits	**20**	**30**	**-**	**40**
Johannesburg	16	20	25	33
Cape Town	17	21	25	37
Durban	21	25	27	37
Port Elizabeth	18	22	24	38
Bloemfontein	16	23	30	38
East London	18	21	25	41
Kimberly	18	25	31	40
Polokwane	19	23	29	37
Skukuza (Kruger Park)	21	26	32	38
Nelspruit	19	23	28	40

Table. 1: Average and maximum temperatures recorded for some locations in South Africa.

Monthly average temperature: the calculated monthly average ambient air temperature at the installation site – equal to half the sum of the average of the daily maxima and the average of the daily minima during a particular month (over many years). For air-cooled, oil-immersed transformers, the monthly average temperature, for the hottest month, should not exceed 30°C.

Maximum ambient air temperature: the upper limit of the permissible ambient air temperature. For air-cooled, oil-immersed transformers, the maximum ambient should not exceed 40°C.

It is important to note that the above temperature limits are used to determine the allowable temperature rise limits of the transformer. They correspond to the normal transformer temperature rise limits of 60 K and 65 K for the transformer top oil and windings respectively. The normal temperature-rise limits apply unless the enquiry and contract indicate "unusual service conditions". In such cases the limits of temperature rise are modified. If the temperature conditions at site exceed one of these limits, the specified temperature-rise limits for the transformer shall all be reduced by the same amount as the excess. Many users loosely specify ambient air temperature conditions, without necessarily understanding or defining whether they are referring to the yearly average, monthly average or maximum ambient air temperature.

Transformer nameplate and continuous output power

In accordance with SANS 780 and SANS (IEC) 60076-1, the transformer nameplate is required to include, amongst other ratings, the rated power (in kVA or MVA), the rated voltages and rated currents. Note that the secondary rated voltage is the transformer no-load voltage. In the case of SANS 780 distribution transformers (as specified for in miniature substations), the rated (no-load) secondary voltage is the appropriate system nominal voltage increased by 5%. This is done primarily for voltage regulation reasons to compensate for the transformer impedance and volt-drop on the LV networks. For example, the no-load secondary voltage for three-phase transformers used in 400 V systems is 420 V. What many people do not realise is that this specific requirement of SANS 780 effectively de-rates the output power of the transformer by 5%. This is because the rated secondary current is determined based on the transformer rated power and rated no-load secondary voltage.

For example, the maximum continuous power a 500 kVA distribution transformer can deliver at nominal voltage (i.e. 400 V) is 475 kVA. A 1000 kVA transformer can deliver 950 kVA. So before the transformer is even installed inside the enclosure of a miniature substation, the transformer is unable to deliver its rated power at the system nominal voltage. The next issue to consider is the effect of the enclosure on the internal ambient temperature inside the miniature substation.

Example of an 800 kVA miniature substation installed at a solar farm.

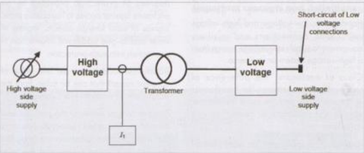


Fig. 4: SANS 62271-202 alternative temperature-rise method.

Substation class of enclosure

A foundational principle of SANS 62271-202 (and thus SANS 1029) is that the key components housed in the miniature substation, being the HV switchgear (e.g. RMU), the transformer and the LV switchgear (LV Assembly) are each required to be designed and type tested as individual components in accordance with their own product standards. Once assembled in the complete prefabricated substation, the correct design and performance of the prefabricated substation as a whole are verified by means of relevant additional type tests described in SANS 62271-202. These tests include:

- Temperature rise tests on the complete substation
- Relevant tests on the HV and LV interconnections (where applicable)
- Mechanical and corrosion tests (e.g. IP Code)
- Internal arc tests

For the purposes of this paper, the authors are only concerned with the temperature rise tests.

Accordingly, the HV switchgear, the power transformers and LV switchgear are each provided with their own individual nameplates, as defined in their respective product standards.

The prefabricated substation is designed to be used under normal service conditions for outdoor switchgear and controlgear according to SANS 62271-1. Inside the enclosure it is assumed that normal indoor conditions prevail according to SANS 62271-1. However, the ambient temperature inside the enclosure of the prefabricated substation will be different to the (surrounding) ambient temperature as defined in the previous section. Note that SANS 62271-202 (and thus SANS 1029) only covers designs using natural ventilation. Therefore, specified requirements such as the enclosure IP Code may have a profound effect on the internal ambient temperature and thus the temperature rise of internal components.

If the ambient temperature inside the substation is higher than the limits fixed for the components in their respective product standards, de-rating may be necessary. A transformer loaded with rated normal current inside an enclosure has a temperature rise which is higher than when tested on its own in free-air conditions, and the temperature limits as defined in SANS 60076-2 can be exceeded. The maximum hot-spot temperature of the transformer should be maintained irrespective of the enclosure, and therefore, it may be necessary to de-rate the transformer to ensure that this hot-spot temperature is not exceeded.

The concept of the "class of enclosure" is based on this fact and effectively makes provision for the conditional de-rating of the transformer once installed inside the miniature substation. Accordingly, the service conditions of the transformer are determined according to the local outside service conditions and the class of the enclosure. This enables the transformer manufacturer or user to calculate its possible de-rating using Annex DD of SANS 62271-202.

The required class of enclosure should actually be selected from the yearly average ambient temperature at the installation site, the required load factor and the actual temperature rises of the transformer on its own. Alternatively, for a given class of enclosure, the permissible load factor of the transformer depends on the temperature rises of the transformer and the yearly average ambient temperature at the substation site.

In most cases in South Africa, the required class of enclosure is not specified and is often ignored or left to the manufacturer to decide. Furthermore, manufacturers themselves do not understand the concept of "class of enclosure" and it often comes as a surprise to many users and manufacturers when they discover that their miniature substation is simply unable to continuously deliver the transformer's rated power under certain conditions. The enclosure class is required to be confirmed by test according to SANS 62271-202.

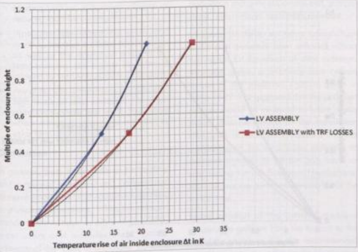


Fig. 5: Internal LV compartment ambient temperature rise of a 1000 kVA miniature substation.

Few manufacturers have conducted temperature rise tests in accordance with SANS 62271-202 to verify the class of enclosure, and in many cases the manufacturer is unable to state what class of enclosure is being offered.

If the user is unaware of what class of enclosure has been offered, this can have significant and/or dire implications on the ability of the transformer to deliver its rated maximum power – particularly if a high class of enclosure is unknowingly offered. Furthermore, manufacturers offering better (i.e. lower) classes of enclosures at a cost premium may be disadvantaged – whereas in actual fact the manufacturer is offering a miniature substation that can deliver higher output power. However, in both cases, the transformers themselves may well comply with the temperature rise requirements of SANS 780 and SANS 60076.

Note that it is possible for a manufacturer to assign to the same enclosure different classes corresponding to different values of power and losses of the transformer. For example, a 5 K class of enclosure could be assigned when housing a 315 kVA transformer whereas a 10 K class of enclosure might be assigned when housing a 1000 kVA transformer (i.e. having higher total losses) in the same enclosure. It should further be noted that if an enclosure is tested for the highest transformer power and losses, the class of enclosure achieved may automatically be assigned for all transformers having lower power and losses – without the need for further testing. Such rules covering the extension of the validity of type tests carried out on prefabricated substations are currently being drafted into a new IEC standard.

Using the guidelines provided in Annex DD of SANS 62271-202, it is possible to determine the possible de-rating of a transformer based on the class of enclosure and the yearly average ambient temperatures at the installation site of the miniature substation. Fig. 1 has been extracted from Annex DD of SANS 62271-202. First, select the curve applicable for the class of enclosure. Then select the yearly average ambient temperature for the substation site on the vertical axis using the axis corresponding to the top oil and winding (O/W) temperature rise limits of the transformer outside of the enclosure. The intersection of the class of the enclosure curve and the ambient temperature line gives the load factor of the transformer allowed.

There are two ways in which this graph can be used.

- The first is when the user specifies an ambient temperature that is higher than one of the standard temperatures as defined in SANS 60076-2. For example, the maximum ambient temperature is stated as 50°C (i.e. 10°C higher than the maximum allowable ambient of 40°C). In this case the allowable transformer temperature rise limits are reduced by 10 K to 50 K and 55 K for the top oil and winding respectively. The appropriate Y axis is then selected to determine the allowable load factor depending on the class of enclosure.
- Alternatively, if the actual transformer temperature rise values obtained are lower than those allowed by the SANS 60076-2 (e.g. 50 K and 55 K for the top oil and winding respectively), then for the standard ambient temperatures, the allowable load factor would be greater than 1 (i.e. 1,1 in this case).

Therefore, depending on the class of enclosure, the transformer temperature rise and the actual service conditions, the transformer and thus the output power of the substation may well need to be de-rated. Conversely, if the conditions are favourable, the transformer could be up-rated.

The next factor to consider is the effects of solar radiation on the enclosure.

Effects of solar radiation

The temperature rise type tests for the HV switchgear, LV switchgear, transformer and complete prefabricated substation currently do not take into account the effects of solar radiation. Only until very recently has a type test for LV power switchgear assemblies used in PV applications been proposed in annex DD of a committee draft (CD) of IEC 61439-2. It is fairly intuitive to appreciate that solar radiation on the miniature substation housing does have a direct effect on the internal ambient temperature of a miniature substation and thus the temperature rises of the various components – in particular the transformer and LV assembly.

The most onerous solar radiation effects on the miniature substation are assumed to be mid-morning or mid-afternoon when the top, back or front and one adjacent side of the substation enclosure is subject to solar radiation. At these times during the day, the solar radiation is approximately 90% of the radiation experienced at midday (i.e. 1,2 kW/m²). For the duration of the temperature rise test, radiant heat lamps are used to simulate the effects of solar radiation on the top, front or back and one adjacent side of the tested substation. Fig. 2 shows the proposed arrangement of radiant heat lamps for temperature-rise test with simulated solar radiation. The radiant heat lamps are arranged so that the average solar irradiance received by the substation under test, perpendicular to the surface being considered is:

If the manufacturer or user proposes to use different external colours of the substation, the substation test shall be done with the darkest colour as this represent the worst case.

The authors, through their participation in the international working group (maintenance team) responsible for IEC 62271-202 have proposed that the effects of solar radiation are in future taken into account in the type tests given in IEC 62271-202. It will be proposed that a test set up similar to the one described in Annex DD of IEC 61439-2 be used. The authors plan to propose a new variation of class of enclosure which also takes the effects of solar radiation into account.

Experience with temperature rise type testing to SANS 62271-202

SANS 62271-202 makes provision for two methods for conducting the temperature rise test on a miniature substation. The preferred method requires two separate power supplies – as shown in Fig. 3. The high-voltage side supply is used to supply the total rated transformer losses to the incoming MV switchgear terminals with the secondary side of the transformer short-circuited – in accordance with SANS 60076-2. The second supply is used to supply the LV assembly in accordance with SANS 61439-1 with the rated secondary current of the transformer and with the LV assembly isolated from the transformer and short-circuited at the point of isolation.

Top	$[0{,}9 \times 1{,}2/\sqrt{2}]$	$= 0{,}76\ kW/m^2$
Front or back	$[0{,}9 \times 1{,}2/(\sqrt{2} \times \sqrt{2})]$	$= 0{,}54\ kW/m^2$
Side	$[0{,}9 \times 1{,}2/(\sqrt{2} \times \sqrt{2})]$	$= 0{,}54\ kW/m^2$

The alternative method can be used if the test facility only has one source of current (as is the case in most test facilities in South Africa) or the design of the miniature substation makes the connection arrangements of the two sources of current impossible. It requires only one power supply connected to the high-voltage side of the miniature substation. The test is conducted with the LV assembly connected to the transformer secondary side and with the LV assembly short-circuited at the outgoing terminals or furthest end – as shown in Fig. 4. In accordance with SANS 60076-2 (in the case of liquid-filled transformers), the first stage of the test requires sufficient current to be supplied to generate the total rated losses of the transformer. For the second stage, the current is reduced so as to produce the rated secondary current of the transformer for one hour. While it is not explicitly stated in SANS 62271-202, as the test method is required to be in accordance with the relevant transformer product standard (e.g. SANS 60076-2 for liquid-filled transformers), at the end of the first stage, the transformer top oil temperature-rise is measured and at the end of the second stage, the transformer winding and LV assembly temperature rise values are measured. It is the authors opinion that clarity is required in SANS (IEC) 62271-202 on the two-stage test method given in the transformer product standard and whether the measurement of both the transformer top-oil and winding temperature-rises are required when assessing the acceptance criteria in relation to the temperature class of the enclosure.

Based on the authors' experience with temperature-rise testing of miniature-substations in accordance with SANS 1029, with the provision of optimally positioned and designed ventilation louvres in the enclosure, it is possible to obtain a temperature class of 5 K. In accordance with SANS 61439-1, simulation of the losses generated by the outgoing feeder circuit switchgear and cables is done through the use of heaters installed in the LV compartment. It is important that the information regarding the size and number of heaters provided is included in the type test report for evaluation by the user – as this could easily be overlooked.

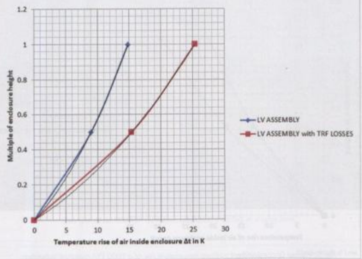


Fig. 6: Internal LV compartment ambient temperature rise of a 630 kVA miniature substation (same enclosure).

It is particularly important to note the significant internal ambient temperature gradient within the miniature substation enclosure. Both calculations and measurements made during temperature rise type testing confirm differences in temperatures of up to 30°C between the bottom of the enclosure and the top.

Historical performance of miniature substation transformers

Considering the various issues raised above, the question has to be asked why the failure to appropriately de-rate transformers that are housed in miniature substations has not resulted in any significant problems or premature transformer failures on site. The following factors are considered to be relevant regarding the performance of miniature substation transformers:

- At many installation sites in South Africa, contrary to popular belief, the yearly and monthly average ambient temperatures are reasonably favourable when compared to those allowed by the SANS 60076-2 standard. Table 1 shows some of the average and maximum temperatures recorded for some locations in South Africa.
- In many cases, miniature substations are installed in residential areas where the typical load profile is substantially cyclic in nature. This implies that in between the morning and evening peak demand times, the transformer has time to cool down when the load is well below the rating of the transformer. Due to the relatively long thermal time constant of the transformer, when the load increases and even exceeds the transformers continuous rating, the winding and oil temperatures often stay within their limits.
- In many cases, large utilities have rationalised their transformer power ratings in order to minimise stock variations and ultimately optimise through economies of scale. In some cases, some utilities only purchase 500 kVA miniature substations – irrespective of the actual size of the load to be supplied – resulting in the fact that the transformer power rating often well exceeds what is actually required.
- The typical Type A or Type B miniature substation designs in accordance with SANS 1029 have the transformer cooling radiators located external to the enclosure, and in some cases (i.e. certain Type A designs), the radiators are not only external to the enclosure but also sheltered from solar radiation by the substation roof.

Having said that, in many cases the user may not even be aware that their miniature substation transformer is being loaded beyond its designed capability and questions will only be asked if and when the transformer eventually fails prematurely. In other cases, and often to the surprise of the user, the transformer thermal overload protection (e.g. linked to the top oil temperature thermometer – if fitted) may trip with a transformer load factor of less than 1.

In the majority of cases, problems relating to the ability of miniature substation transformers to deliver their maximum rated power have surfaced in the following cases:

- Industrial or commercial areas where the load profile is less cyclic (i.e. continuous loading with no in-between periods of reduced load for cooling down).

- Installation sites where the yearly and monthly average ambient temperatures as well as the maximum ambient air temperatures are higher than those allowed by the SANS 60076-2 standard.
- Any of the above conditions coupled with high levels of solar radiation. The most common example and worst case being where miniature substations are used in solar farm applications.

Conclusion

In general, there is very little understanding of the thermal behaviour and performance of transformers and other equipment installed in miniature substations. While the relevant standards have been in place since 2010, most users and manufacturers remain unaware of the "class of enclosure" concept and its impact on the rating of the transformer (and LV assembly) housed in the enclosure. Temperature-rise type testing in accordance with SANS 62271-202 in general is not done and most users expect that their miniature substation transformers are able to deliver the power indicated on the transformer nameplate. This is particularly evident when looking at the increasingly popular "high-risk" miniature substations being designed and built with 6 mm steel enclosures and, in many cases, with minimal ventilation provided.

Miniature substation enclosure colours have in the past generally been selected without any regard for the effects of solar radiation. Avocado green, a relatively dark colour, is one of the preferred colours given in SANS 1029. It is suggested that the preferred colours should be reviewed in future. Users should also be mindful of the installation orientation of miniature substations and that positioning of the transformer radiators to minimise exposure to the sun (e.g. south or east facing for the Southern Hemisphere) can optimise the performance and life of the transformer.

Being mindful of the internal ambient temperature gradient from the bottom to the top of the enclosure, it is also recommended that LV equipment, and in particular sensitive electronic equipment, be positioned as low down as possible. Due to the maximum conductor temperature limit of 70°C for PVC insulated LV interconnections, particular attention must be given to the location of these cables within the enclosure. It is recommended that cable insulating materials that can operate at a higher temperature be considered in order to minimise thermal aging.

The authors also propose that a main circuit resistance measurement test be carried out on the LV interconnections and included as a routine test in SANS (IEC) 62271-202 as no such routine test currently exists in this standard. This will assist in verifying the integrity of the LV interconnections between the transformer, the main circuit-breaker and the LV assembly.

Finally, it is recommended that purchasers should ensure that manufacturers have carried out the required temperature rise type tests given in SANS 62271-202 on at least the highest miniature substation power rating offered. An IEC technical report is currently being developed to assist users with the extension of the validity of type tests carried out on a particular miniature substation to another miniature substation. In the interim, it would be prudent to ensure that, for a given enclosure design, the total losses generated as well as the current densities of the LV assembly are equal to or lower than those of the type tested miniature substation.

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Impact of commercial/industrial SSEG installations on MV networks

by Geeven Moodley, Dr. GD Jennings, V Pillay, N Reitz and J Govender, Digsilent Buyisa

With the increasing levels of small-scale embedded generation (SSEG) being implemented into municipal networks in South Africa at low voltage (LV) level, there is concern about the impacts these embedded generators will have on the technical performance of the municipal networks at medium voltage (MV) level.

While several studies have been done, much of the focus has been on the financial impacts for the distributors with very little technical impact studies available. This paper presents results of studies that were done considering an MV network in the Polokwane municipality and the impact varied levels of SSEG penetration could have on this network.

The network had predominantly industrial customers on dedicated feeders with some residential and commercial customers on shared feeders. Utilising NRS 097-2-3 [2] as a connection guideline, different penetration levels of SSEG installations were modelled and the impacts on the voltage regulation, power flows, harmonics and the revenue from energy sales was studied.

In 2014, the authors released a paper on the impacts of SSEG on LV networks [1]. The paper utilised "academic" networks to perform technical impact studies. Subsequent to the release of the paper, there has been much focus on the impacts of SSEG on MV networks. Based on this need, the authors investigated the impacts of SSEG (implemented at LV levels) on the MV networks. For these studies an actual municipal network was utilised to give the study results more credibility and help the technical staff operating distribution networks gain a better understanding of the impacts of SSEG on the electrical networks. The studies also considered the impacts on the energy sold and hence the financial implication to the municipality.

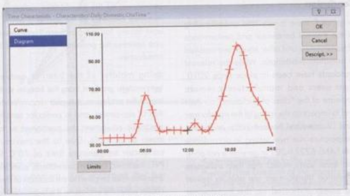

Fig. 1: Residential load profile.

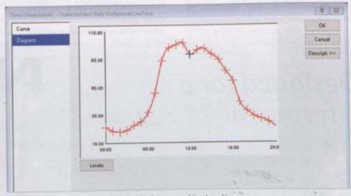

Fig. 2: Commercial load profile.

Simulation model assumptions

In order to perform such studies it is important to choose a network where the customer classification can be easily identified. During the DANIDA project, the Polokwane municipality was identified to have an area (network) whereby the customer classification could be easily identified.

Laboria has 32% residential customers, 58% industrial customers and 10% light commercial customers. The network has a total installed capacity of 33 200 kVA of MV/LV transformers. All industrial clients are on dedicated MV/LV transformers, with residential and commercial customers on shared LV feeders which are operated as ring feeders.

All studies were done using Digsilent's PowerFactory software, Version 2017.

Load profiles

Different customer classes have different load profiles. Once the customer classes were identified, typical load (consumption) profiles were derived for each customer class. All load profiles were normalised. Fig. 1 shows the typical load profile of a residential client with an evening peak occurring between 18h00 and 19h00. Figs. 2 and 3 show the load profiles used for commercial and industrial customers in the studies.

There is no active metering of load consumption at each of the MV/LV transformers. For the study purposes it is assumed that the MV/LV transformers can load up to 100% of their installed capacity. No diversity is applied to the loading and is based on the customer load profile connected to that transformer.

The following assumptions were made with respect to loading in the chosen networks:

- Peak load occurs in winter.
- Summer peak load is 80% of winter peak load.
- Minimum load peak occurs in summer and is equal to 25% of peak winter load (December and January due to industry shutdown).

SSEG generation profiles

For these studies only PV installations are considered. Utilising publicly available generation records from SMA, typical daily profiles from SMA inverters installed with the Polokwane network was downloaded and analysed [3]. The generation profiles of the inverters were based on a 4 kWp, Sunny Tripower 6000TL-20 model. The daily generation profiles were then statistically analysed and typical daily generation profiles were created considering summer and winter as well as cloudy and sunny days. The PV generation is shown in Fig. 4.

In winter the peak PV generation was found to be less than in summer i.e. it was approximately 80% of the summer peak.

Sizing of SSEG installations to customer classes

Utilising NRS 097-2-3 [2] as a guide, the following assumptions were made with respect to the size of SSEG installation at each customer's site.

- NRS connection criteria is applied based on shared or dedicated LV feeder connection. All industrial clients have dedicated MV/LV transformers hence dedicated LV supplies. As such the criteria was applied whereby all industrial customers can install up to 75% of MV/LV transformer capacity in SSEG.
- Residential customers are connected using a 60 A connection breaker (notified maximum demand (NMD) = 13,8 kVA). These customers are on shared LV feeders as such a residential customer will be limited to 25% of the total NMD, i.e. the SSEG installation is limited to 3,45 kVA (3,45 kW).
- Commercial customers are also on shared LV feeders hence will also be limited to maximum SSEG installation size of 3,45 kVA (3,45 kW).
- NRS stipulates in the simplified criteria that the embedded generation should be limited to less than or equal to 15% of the MV feeder peak. Since there is no active monitoring of the MV feeder peak, to apply this criteria is not possible. As such it could not be considered in the studies.
- SSEG penetration levels are considered as follows:
  - All clients are assumed to have SSEG installed on site and the installed size is the maximum allowable size.
  - 0% penetration means no SSEG is generating power regardless of the time of day.
  - 100% penetration means that every customer's SSEG installation is generating power up to a maximum allowed by the PV generation profile.
  - For SSEG penetration levels between 0 and 100%, the generation at each of the customer's SSEG installation is limited to the specified percentage and also limited to the maximum allowed by the PV generation profile.

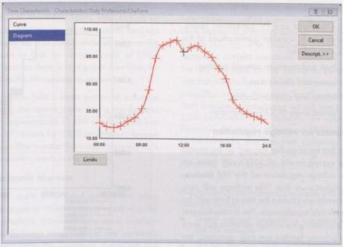

Fig. 3: Industrial load profile [4].

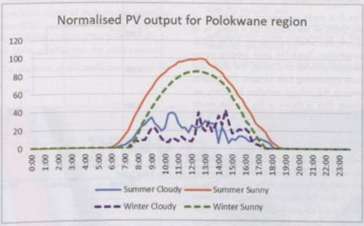

Fig. 4: Normalised PV generation profiles for PV inverters in the Polokwane region.

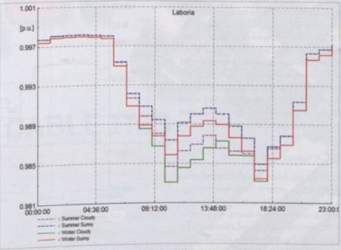

Fig. 5: Voltage variation for a sunny vs. cloudy day in summer and winter for Laboria.

Study criteria

Since the load and PV generation varies, studies had to consider combinations of the following criteria:

- Peak and minimum network loading
- Sunny and cloudy days
- Winter and summer loading
- Varied levels of SSEG penetration

Impacts on voltage regulation

The first set of studies focused on the impact the varied levels of SSEG will have on the voltage regulation of the MV feeders. Speculation is that "the voltage will vary tremendously causing the taps to burn out" on the HV/MV transformers. The studies focused on monitoring the voltage variation and since the Laboria feeders are ring operated, the voltage was monitored as close to the centre of the feeder as possible.

Peak network loading

The first study considered the impact of the SSEG on the voltage, for a sunny vs. a cloudy day, when considering 100% SSEG penetration. Since the peak loading varies between summer and winter, the study was done considering both seasons. For Laboria network the voltage variation for sunny vs. cloudy days is shown in Fig. 5. The results show that the voltage variation is <1% for both summer and winter in both networks, thus little cause for concern.

The next studies focused on the effect the varied levels of SSEG penetration will have on the voltage regulation of the feeders. Figs. 6 and 7 show the voltage variance at the centre of Laboria's longest feeder, for both summer and winter loading, with the SSEG penetration levels varied from zero to 100%.

The results again indicate that voltage variation on the feeders is less than 1%. As expected the impact on the voltage during the day with the SSEG installations is noticeable, but still within an acceptable variance range. During the evening peak there is no effect with the network experiencing maximum voltage variation (from low loading). In the Laboria network the SSEG installations assist the voltage regulation during the day when the network experiences high loading and reduces the voltage variation between midday and night.

Minimum network loading

The voltage regulation was also studied when the network is experiencing low loading. This is typically in December and January (holidays, company shut downs, etc.), hence only the summer loading was considered for these studies. Fig. 8 shows the voltage at the centre of the longest feeder in Laboria with

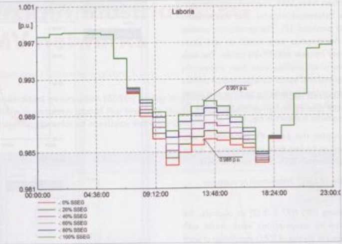

Fig. 6: Voltage variation with peak summer loading with varied levels of SSEG penetration.

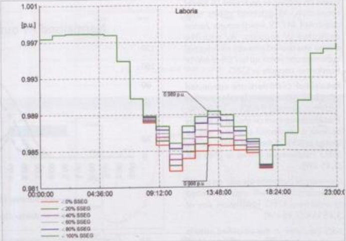

Fig. 7: Voltage variation with peak winter loading with varied levels of SSEG penetration.

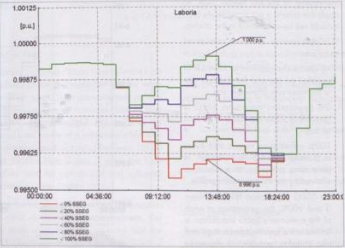

Fig. 8: Voltage variation with minimum summer loading and varied levels of SSEG penetration.

varied levels of SSEG penetration. The results indicate that at certain penetration levels the voltage during the day is higher than the voltage at night. This is clearly shown in Fig. 8 where the midday voltage is higher than the voltage at midnight.

Impacts on power flows

Also of concern is the impact the varied levels of SSEG generation will have on the power flows into the MV network (and associated energy sales). The power at the infeeds into the HV/MV transformers was monitored, when considering varied levels of SSEG penetration.

Peak network loading

Figs. 9 and 10 show the variation in power flows into the Laboria network when considering the summer and winter peak loading. The results show a significant decrease in power at midday when the SSEG installations are producing maximum output. As expected in summer the SSEG outputs are at maximum hence having a greater impact on the power drawn from the HV network.

Minimum network loading

The impact of the varied levels of SSEG penetration was also considered for minimum network loading. Since this occurs in December/January only the summer load was considered. The studies show very interesting results in that for certain levels of SSEG penetration there is now power flow from the MV to the HV network as shown in Fig. 11.

In Laboria (with a large portion of industrial clients) the reverse power flow is significant in that approximately 11 MW can flow back into the HV network for 100% penetration. Reverse power flow is noted from approximately 40% penetration levels in the network.

Harmonic impacts

Small scale embedded generation often makes use of inverter technologies in order to produce power. While most modern manufacturers have reduced the harmonic output from the inverters, there are still some harmonics generated. Utilities are often concerned that when there are large penetration levels of SSEG in the network, the cumulative impact of the harmonic injections from SSEG inverters can become significant thus adversely affecting the power quality to all clients supplied from the utility's network.

The objective of this study was to quantify the impacts the harmonics would have in the network being studied when considering worst case harmonic injection currents permitted by the IEC [5]. The maximum allowable harmonic current injections permitted by the IEC was used as the harmonic current injection source for each of the inverters in the simulation model. Harmonic loadflows were then executed, considering varied levels of SSEG penetration in the network. The voltage harmonic distortions, at the main MV busbar of the networks, was then then compared to the maximum allowable planning voltage harmonic limits according to NRS for MV networks [6].

The following assumptions are made with the network model:

- Linear network impedance assumed for the HV network.
- No skin effect on cables considered hence this will lead to worst case calculated distortion levels.
- No background harmonics are considered from the network side.
- All loads modelled as impedance loads with only the cable capacitance of the networks considered [7].

The results for harmonic studies are shown in

Fig. 12. The results indicate the following:

- The voltage harmonics increase with increased levels of SSEG penetration and the results are as expected.
- For lower order harmonic <20th order, the harmonics are well below the NRS limits, even with 100% penetration.

For higher order harmonics (>20th) the voltage harmonics exceed the allowable NRS limits. Further investigations of this showed that there is a network resonance around the 38th order, as shown in Fig. 13. This is consistent with the frequency response of LV and MV cables used in the networks, thus resulting in the high voltage harmonics.

The results of the studies for these networks, show that even with extremely high SSEG penetration levels, the impact of the PV inverters on the network harmonics is within acceptable limits. It must be noted that these harmonics study results are heavily dependent on the network that is being studied since clients may also have power factor correction and filtering equipment that will affect the harmonics in the network. Furthermore some networks may contain equipment that may cause network resonances. These resonances could cause harmonic distortions that exceed NRS planning guides. It is highly recommended that each network be studied independently in order to assess the impacts SSEG will have on the harmonic distortions.

Impacts on energy sold (revenue)

With increased levels of SSEG penetration there is a significant impact on the power that is drawn from the HV network into the MV network. This will have a direct impact on the energy sales by the municipality in the network being studied. Since the studies are conducted using load and generation profiles over a typical day, the effect on the energy sales can also be quantified. For these studies it is assumed that

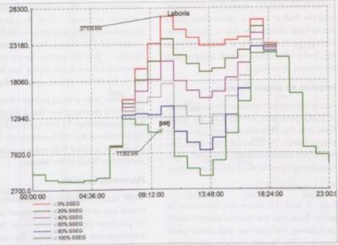

Fig. 9: Power flow with peak summer loading and varied levels of SSEG penetration.

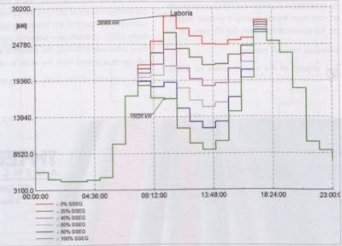

Fig. 10: Power flow with peak winter loading and varied levels of SSEG penetration.

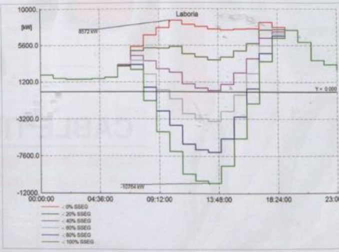

Fig. 11: Power flow with minimum summer load and varied levels of SSEG penetration.

Customer	Tariff (c/kWh)
Domestic	177
Commercial	151
Industrial	65

Table 1: Fixed tariffs assumed for the sale of energy.

Seasonal loading	Daily income from energy sales
Summer (peak)	R408 197
Winter (peak)	R445 999
Summer (minimum)	R139 296

Table 2: Approximated daily income from energy sales, depending on the season and loading.

all clients are on a fixed tariff i.e. no time of use tariff is considered. The tariffs considered are shown in Table 1.

Considering the network with no SSEG present (0% penetration) then the total revenue that can be expected per day, is given in Table 2. As the level of SSEG increases the expected revenue from energy sales is reduced. For Laboria network the expected daily reduction in energy revenue is shown in Fig. 14. With the Laboria network having more industrial clients with larger SSEG installations, the reduction in daily energy sales is expected to be greater. For 100% SSEG penetration the daily reduction in energy sales is as high as 37% in summer and 25% in winter. Again the reality is that while industrial clients may have more financial resources to purchase SSEG, not all customers will install SSEG. Assuming a very favourable penetration rate of 60%, then the daily reduction in energy sales can be as high as 22% in summer and 15% in winter.

For peak loading cases there is no reverse power flow from the MV to the HV network. For the minimum loading cases however, it has been shown that there is reverse power flow from specific levels of SSEG penetration and above. Fig. 15 shows the impacts on the daily revenue for summer minimum loading in Laboria. As can be seen, all excess power that is generated from SSEG is actually income thus reducing the loss of energy sold.

It must be noted that since the municipality has no official feed-in tariff, excess power that is generated from SSEG installations, comes at zero cost. However this power can still be sold to nearby customers, thus this SSEG power becomes a source of income for the municipality (with no cost). It must be further noted that the loss of revenue from energy sales is not entirely incurred by the municipality since they do not have to pay Eskom for this unsupplied energy. Also the losses for transporting the power from Eskom

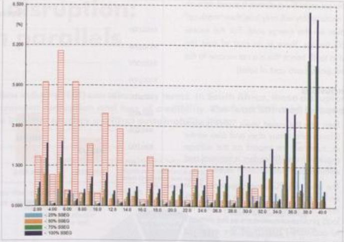

Fig. 12: Harmonic distortion levels for varied levels of SSEG penetration. NRS limits shown as hatched bars in the background.

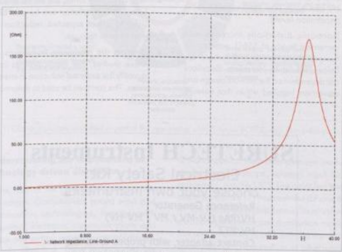

Fig. 13: Network resonance due to cabling and transformers.

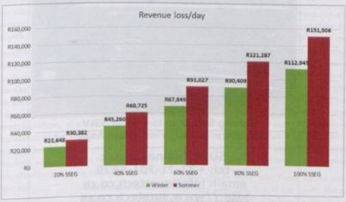

Fig. 14: Laboria revenue reduction with varied levels of SSEG penetration, for peak loading on summer and winter days.

intake points to the customer is saved. As such the municipality will only lose their "mark-up" portion on the energy sold. For the excess SSEG energy, there is no cost of sale (no feed in tariff) hence this is a net income to the municipality (zero cost of sales).

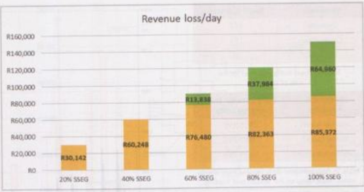

Fig. 15: Laboria revenue reduction with varied levels of SSEG penetration, for minimum loading. Impact due to SSEG infeed also shown.

Conclusions

The results of the studies have shown:

- Even with the varied levels SSEG outputs (cloudy and sunny days and also winter vs. summer) the impact on the voltage regulation on MV feeders is minimal and within acceptable variation levels.
- The level of SSEG penetration does have an impact on the power flow in a network and it is important to accurately model the load profiles of customers in the network to accurately determine the expected changes in power flows.
- Even when following the NRS 097-2-3 guidelines, there are certain conditions whereby reverse power flow from MV to HV can occur (low loading, high SSEG penetration levels).
- Harmonic distortions increase with increased levels of SSEG penetration however these harmonic distortions are below NRS limits. Harmonic distortions are dependent on the network design and equipment installed within that network hence each network must be studied independently to determine the impacts the SSEG will have on that network.
- With no-feed in tariffs, any excess energy from SSEG installation can be sold and used to offset expected reduction in energy sales revenue.
- Utilising the modelling techniques of these studies, the municipalities can quantify the expected reduction in energy sales. This can then be used to determine accurate fixed network charges in order to minimise the effect of reduced energy sales.

Acknowledgements

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References

[1] GV Moodley, GD Jennings, V Pillay: "Typical technical behaviour of LV networks, with varied levels of renewable penetration", AMEU Convention, Johannesburg, 2014.

[2] NRS 097-2-3:2014: "Grid Interconnection of Embedded Generation, Part 2: Small-scale embedded generation, Section 3: Simplified utility connection criteria for low voltage connected generators".

[3] www.sunnyportal.com/Templates/PublicPageOverview.aspx?page=0369a752-55a9-4534-bea5-a80f6779273e&plant=139ab32e-5b85-440a-ba9b-a32ae06a99f38&splang=en-US

[4] JA Jardini, CM Tahan, MR Gouvea, SU Ahn and FM Figueiredo: "Daily load profiles for residential, commercial and industrial low voltage consumers", IEEE Transactions on power delivery, 15(1), pp.375-380, 2000.

[5] Limits for harmonic current emissions: "EN 61000-3-2:2014 Electromagnetic compatibility (EMC) — Part 3 – 2: Limits for harmonic current emissions (equipment input current ≤16 A per phase)"

[6] NRS 048-4:2009 Edition 2: "Electricity Supply – Quality of Supply Part 4: Application practices for licensees", ISBN 978-0-626-22829-3.

[7] CBI-Electric: African Cables: "Low Voltage PVC Cables, 1 kV housewire copper single core 1,5 mm to 16 mm pdf".

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Global electricity disruption: The South African parallels

by Paul Vermeulen, City Power Johannesburg

Disruptors to the global electricity distribution industry (EDI) can take many forms. In South Africa, these disruptors include sluggish EDI transformation, government corruption and loss of credibility. The local EDI may, however, leap-frog the transition process before the industry reaches a critical sustainability limit.

The City of Johannesburg's first serious look at disruptions in the electricity business happened in February 2014, prompted by the mayoral committee's concerns of declining sales volumes, spiralling tariffs, out of control revenue losses and, of course, what was then a constant threat of load shedding. Energy efficiency, demand side management and alternative energy sources came to the fore like never before, but could only partly address the problems. It was clear – the mainstay of the city's revenue generating entities was unable to deliver as it had in the past, and without grants and subsidies the electricity "core business" was unable to generate a surplus.

Fig. 1: Global disruptors identified as part of the new energy plan (Source: EON Energy Plan presentation).

What's wrong with the cash cow?

Three disruptions have already taken effect and have eroded the asset called electrical load. These were the sustained economic down-turn since 2008, spiralling tariff increases with the price elasticity of demand reaching a tipping point, as well as structural changes occurring within the energy system of the city itself. The structural changes, among them the use of new renewable energy sources and gas alternatives, prompted the mayoral committee to consider changing the charter for City Power from being just a narrow electricity distributor into a new entity, a more sustainable "energy company" providing services using more than just centralised grid power. What form this company would take was most uncertain at the time. To try to define the form and secure future revenue from energy services, EON Consulting was engaged to develop a new energy plan for the city and a new business model for City Power.

The first step was, in consultant speak, an "environmental scan". This included a look at what was happening globally, yielding the picture in Fig. 1.

The wheel of global disruptors definitely does apply locally, albeit with some variations owing largely to the fact that very little real industry reform has occurred in South Africa since the writing of the Energy White Paper in 1998 which was widely regarded as the blueprint for the industry at the dawn of the new democracy. This paper is intended as a South African view of each disruptive spoke of the wheel, perhaps with some tongue-in-cheek commentary.

Understanding the implications of technology driven disruption.

At the root of the global disruption is new technology. Competitively priced wind and photovoltaic technologies, together with ubiquitous electronic communications and cheap computing power to control things, is really what it is. These technologies are changing the energy landscape across the globe. Energy storage, the newest kid on the block, is also poised to accelerate the changes at every point along the electricity distribution value chain, and is already on a similar downward price path to what the world has seen with photovoltaic panels [1] (see Fig. 2).

So much for the technology or "engineering" aspects of the disruption... In attempting to understand what this really means, [2] expresses the impacts of the changes in more socio-economic terms. In these terms, the disruption is rather the decentralisation, democratisation, digitisation and de-carbonisation of the world's energy systems. These are powerful new weapons indeed, particularly when it comes to dealing with monopolised power supply, from a consumer's perspective.

SALGA is likewise concerned about the future of the EDI, having conducted a series of workshops on the matter over the last few years. The workshops included input from academics, notably UCT. The point has been made (Trollip, 2017) that both the IEP and the IRP are still based on last century's centralised electricity generation and distribution models that are completely at odds with this disruptive quadruple "D" phenomenon. In other words, our latest IRP is completely out of touch with reality. It also excludes consideration of utility scale energy storage and electric vehicle developments (see Fig. 2).

Around the world, consumers have come to view utilities as a kind of grudge payment. For a century, the consumer simply had to pay the "regulated tariffs" and had no choices or options. People do not like this aspect of monopolies, no matter which continent they live on. Throw in an element of graft and corruption, some erroneous billing and unjustified cut-offs and you have a severely disliked industry with openly rebellious customers on your hands, to whom the idea of grid defection has great appeal. This current reality is our own unique brand of disruption.

When prices were low, these issues were perhaps tolerable, but in the South African context the 500% increase in electricity prices over the last ten years accompanied by intolerable bouts of load shedding has changed our energy system forever. The price elasticity of demand, considered a non issue by the industry for many years prior, kicked in, consumers made serious investments in energy efficient lighting and appliances, switched to alternative energy carriers such as gas for cooking and water heating and ignited a fresh public interest in personal renewable energy systems to reduce their dependency on the grid. In many cases, those unable to invest in these measures simply resorted to electricity theft, evident in our growing trend of increasing losses. The honest consumers, once their free allocation of kilowatt-hours have been used up, revert back to cheaper candles and paraffin, despite having access to the grid.

The attitude towards the local industry as a whole has deteriorated by an order of magnitude following the exposed corrupt activities and involvement in state capture of Eskom's board and executive management, and the mismanagement identified in some municipalities. The new "DDDD" options, particularly when the cost of storage reduces to an affordable level, will provide a real alternative to the grid for affluent residential customers and commercial enterprises alike.

With all the negative industry sentiment about, it will be difficult to sell the grid for the value it can bring in an efficient greener energy future, providing seamless load balancing services and a marketplace for new green energy generation opportunities. The industry has perhaps a very narrow window of opportunity to change these perceptions and keep these players connected to the grid.

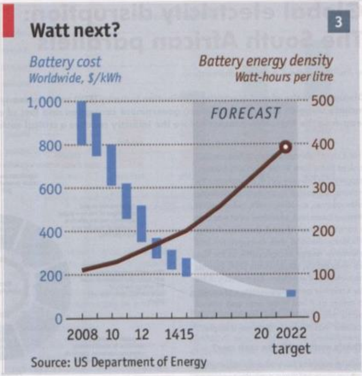

Fig. 2: Energy storage is set to change the electricity distribution value chain.

Infrastructure investment

Much of the urban infrastructure was put into service in the 1960s and 1970s and needs to be replaced as the equipment has reached the end of its intended design life. Nowadays, virtually all available capital is spent on new intake substations and electrification with very little on refurbishment, particularly the refurbishment of the "last mile" in the older established business centres and surrounding suburbs. At last review, the EDI maintenance backlog was estimated to be in the region of R68-billion [3]. The industry is seeing a worsening picture as far as NRS 048 quality of supply standards is concerned and in comparison to the rest of the world, our SAIDI and CAIDI figures are poor. This ongoing disruption is perhaps more like a ticking time-bomb.

Of the funding that has been available over the last decade, one has to question if the best value for spend has been achieved. MFMA procurement regulations have in themselves been disruptive to business. In an asset management business, particularly where the assets are of a technical nature, it makes sense to standardise as far as possible and limit the variety of plant and equipment deployed within each asset class. This is achieved by applying strategic sourcing principles, however these always seem to be at odds with the cyclical competitive bidding processes and short-term contract nature of the MFMA.

An enormous amount of effort is spent by municipal supply chain managers on applying the "rules" of the MFMA, often in conflict with the engineering managers' recommendations. Where supply chain managers and clerks win out, probably ten times that effort is subsequently required from the organisation's limited engineering staff to manage and maintain the random rather than strategic collection of assets that is procured and put into service. The problem only worsens over time.

Changing energy mix and distributed generation

Most municipalities have realised that their retail customers have a right as property owners to invest in energy efficiency and install photovoltaic systems on their properties to supplement the energy they take from the grid. Most do this to contain rising energy costs and the Receiver of Revenue even has tax incentives in place to promote these activities.

In the case the customer "grid-ties" his system and uses the grid for load balancing and as a marketplace to sell any surplus energy he may have, the grid operator remains relevant to, and can retain the customer. To offset revenue losses from the reduced sale of units of energy, the distributor can adjust the tariffs and charges to access the grid and compensate for the loss.

In overseas markets, the big disruptor to utility companies has been regulators insisting on net metering policies or incentivising renewable energy feed-in tariffs that have severely impacted utility revenues.

Here at home, several municipalities have put in place NERSA approved small scale embedded generation tariffs that allow for any surplus put to the grid to be compensated through a process of net billing rather than net metering. In this arrangement, the surplus is effectively "bought back" at a lower rate than what it would be sold to a neighbouring customer.

Regulation being what it is, the NERSA approved buy-back rates to the distributor must be less than the cost of Eskom bulk power. The energy losses associated with the surplus are also significantly less because the

source of the energy is embedded within the network. In South Africa, the intensity of the sunshine is double what it is in Europe, so tariff incentives are perhaps not really needed to promote investment here.

While the municipality may have lost the sales margin on the self-produced and self-consumed power of their new "prosumer", the margin on their surplus, which is immediately sold to their neighbours, is much better than the margin on selling the neighbours good old Eskom power. Without battery storage, it is not uncommon for anything up to half the power produced by a residential customer's PV system to escape to the grid as surplus. This will stay that way until it is cheap enough for them to install energy storage systems to arrest all the fugitives.

Theoretically, 100 000 mid to upper residential customers, each with a 3 kW system on their roof, could contribute seven such surplus kilowatt-hours to the system per day, or collectively provide 700 MWh of low-cost energy to the system each day, out of the 29 000 MWh City Power, for example, needs to meet the City of Johannesburg's daily requirements. Provided the network access charges are adjusted to ensure that revenues are still generated for network maintenance, the improved margin of on-selling the prosumer's surplus energy could make a decent contribution towards reducing the cross-subsidy needed from the business tariffs to help out the low income residential sector. The mid to upper income group may even be willing to actively participate, knowing that they are making a worthwhile contribution to society.

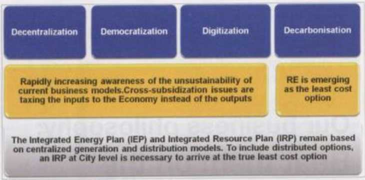

Fig. 2: The disruption from technology advancement expressed in socio-economic terms.

Resisting this particular evolution of the grid really means an opportunity lost and the amplification of the cross-subsidy problems that are already disrupting the municipal surplus derived from electricity sales.

Where the grid operator chooses to make it difficult for the customer to use the grid as mentioned above, the customer, despite an obligation to comply with the national distribution grid code, will either connect anyway and become a potential safety hazard, or configure their system as an independent off-grid system that shuts off surplus generation and uses the grid only as an overcast day backup arrangement. This is the worst case for the distributor, with no means to stay relevant to the customer, and things will get even worse at the time when PV plus storage reaches price parity.

With huge bills to pay for the construction of Kusile and Medupi, resisting the transition is unfortunately Eskom's present approach to renewable energy, as they see both embedded generation on distribution grids and transmission connected REIPPP generation as a loss of market share.

Ironically, the municipalities, treated as a group of "retail" customers, do not seem to have the right to make their own investments in photovoltaic or wind energy systems to supplement the energy they take from Eskom and obtain blocks of energy at a lower fixed price than fossil based energy. A few things trip them up along the way; the IRP and associated ministerial dispensations, the Eskom single buyer cabinet decision of 2007 and the onerous requirements of the MFMA that need to be followed to sign a power purchase agreement for a duration longer than three years.

This is a double disruption for municipal distributors. Their own prime customers can invest in and connect alternative energy systems to power their loads and reduce their energy costs going forward. They themselves are not at liberty, as either retail customers of Eskom, nor as fully fledged distribution system operators, to do the same to contain costs and use the savings towards subsidising their low income residential customers, as they are obliged to do by the national Electricity Pricing Policy.

This is why the City of Cape Town has taken NERSA and the minister of energy to court, seeking an interpretation and declaratory order on Section 34 of the Electricity Regulation Act (2006). The wording is that the minister "may", not "must" or "shall", make determinations on new generation plant for the country. They have a city level IRP that was done by the CSIR which indicates that, by including 170 MW of photovoltaic generation and 220 MW of wind power into their grids, by 2023 their bulk energy purchases will become half a billion rand cheaper. There is a good chance of them winning their case.

Empowered customers

In hindsight, perhaps the most empowering turn of events for the electricity consumer over the last decade has been load shedding. Despite Eskom's current 6000 MW surplus capacity, a number that today is almost meaningless to the average consumer, the initial helplessness and inconvenience of load shedding was permanently burned into the memory of an entire generation. As a result, they now also know of, and better understand their new energy options.

PV system and inverter vendors lamented the times load shedding subsided as regular bouts of load shedding was their best form of advertising and opportunity for customer education. The timing could not have been better as the cost of PV was reducing and the technology was becoming affordable to a greater portion of the population.

Gone are the days of the consumer taking electricity for granted. The paying South African consumer now comprehensively understands energy efficiency and alternative energy sources, and has a plan of how to use them going forward. Load shedding can be argued to have been the most severe of South Africa's disruptors to date and its lingering effects seem to continue in two new forms:

- Firstly, as an ongoing increase in tariffs, needed to fund the cost of the new-builds and settle regulatory clearing account claw-backs, coupled with the consequent "utility death spiral" that feeds on ever increasing tariffs.
- Secondly, as SAIDI and CAIDI figures rise, signalling a deterioration of the security of supply to customers from the effects of load shedding stress on the networks and sustained under expenditure on distribution infrastructure maintenance. Also aggravated by vandalism and theft assaults on the networks.

City Power to date has officially commissioned 8,4 MW of rooftop PV systems and the number of new applications rises monthly. There is a strong suspicion that at least another 30 MW of unauthorised small-scale embedded generation is connected to their grids. The City of Cape Town has commissioned more than this and also recognises that they also have tens of megawatts of unauthorised systems connected to their grids.

Digitisation

Moore's law was an observation made in 1965 that the number of transistors on a computer chip would double roughly every two years. The cost of the chip, however, would not double, which meant that computing power would dramatically drop in cost as time passed. This has held true for several decades and today we see relatively cheap microprocessor based metering and integrated protection and SCADA products being deployed all over the electricity distribution system. These devices have wonderful functionality – perhaps generating far too much unnecessary information in some cases.

Old disc and mechanical relay-based metering and protection units had a lifespan of anything up to six decades. They never required "upgrading" in all that time, only some physical maintenance every few years. The first disruption that came from adopting the new digital technology learning how to configure and use it sensibly.

The second disruption has been that the technology has a lifespan of only a decade if you are lucky. Things develop so quickly that the microprocessors used are obsolete within five years and usually not supported after ten years. Electronic systems age quite quickly and at least one unit will fail before they turn 15. If they are running in a connected mode for automation purposes, when spares run out, all units will have to be replaced. More disruptive is the problem that the PC or laptop originally used to configure and program the devices packs up even sooner and the commissioned configuration data may no longer be available. Or the staff who originally did the work have left the organisation.

The third disruptive factor of digital distribution technology is that it requires the putting in place the capital budgets to support these continuous upgrade cycles. While the cost of the equipment may come down over time, the cost of the engineering resources to do the upgrade work and system re-commissioning does not. Great difficulty and serious engineering effort are required to integrate the variety of newer devices into the existing control systems and the switch to digital equipment becomes a continuous burden to itself as distributors fall into the trap of not increasing their capacity to do the necessary work.

The same problem arises with complex engineering information systems. SCADA, GIS, condition monitoring and outage management systems tend to have a golden period of operation a few years immediately after they are commissioned, but will degrade over time as hardware and more often than not mandatory software upgrades are required to keep the systems functional. Should a municipality have no internal systems integration expertise, "digitisation" will need to include ongoing software vendor support creating another, usually substantial ongoing cost.

The problem is once again aggravated by the rules of the MFMA, which make it very difficult for a municipality to establish a long term relationship with a vendor who offers a fully integrated engineering information system that has off the shelf integrated network planning, GIS, SCADA, outage management and plant condition monitoring functionality.

Market and policy reforms

Two notable non-events, the abandonment of the REDS and parliament's rejection of the ISMO Bill despite both being key elements of the 1998 Energy White Paper, have had serious disruptive effects on the industry.

In the build-up to the REDs, municipal distributors put the brakes on creating debt to address their maintenance backlogs. Similarly, there was no appetite for capital expenditure for network expansion just prior to the REDs being formed. Years went by without the proper infrastructure investment in municipal distribution areas, and it took at least another two years to resume after the REDs were abandoned. A key objective of the REDs was to incorporate smaller struggling municipalities into viable distribution companies. Needless to say, the situation in smaller municipalities has since deteriorated, with many apparently on the verge of collapse.

No independent system and market operator (ISMO) also means no independent power producers outside of the REIPPP program, a program that only got underway because it was underwritten by Treasury in support of South Africa's climate change mitigation commitments.

In the continuing ISMO vacuum, there has been a further development. The vertically integrated Eskom, still clearly dominated by the generation division, remains the nominated single buyer or market operator for the country and has had the power to scuttle the REIPPP by refusing to sign the PPAs beyond bid window 3. This means the REIPPP program, the once shining South African light in the eyes of the rest of the world that has been adopted by many countries as policy for the procurement of renewable energy, is in serious danger of fizzling out, right where it started.

No ISMO has also meant no competition for the generation industry – no real incentives to keep the cost of the new-build in check, and no incentives to keep the costs of primary energy down. Unfortunately, the opposite has happened. Opportunists in both the coal and road transport industries, allegedly with inside help, have made overnight fortunes at the expense of the South African electricity consumer.

One step towards the establishment of an independent power market in the southern African region was the establishment of the Southern African Power Pool in 1995. Ironically, today it is possibly cheaper to source Eskom power from the pool rather than as a South African municipal customer of Eskom. This is evident from a quick analysis of the customer information sheet of Eskom's integrated annual report for 2017 (see Table 1).

While it may be possible for a metro to become a member of the SAPP, the MFMA does not allow any foreign currency trading. Somehow, the city that is often referred to as the economic powerhouse of Africa, cannot trade internationally for its own, and ultimately the country's benefit.

As far as Eskom is concerned, municipal distributors are retail customers and are treated the same as the industrial customers. They are not really considered re-sellers who should be offered true wholesale pricing. If this was the case, the cost to the distributors would be lower than the cost to industry.

Customer category	No of accounts	Sales GWh	% of GWh Sold	Revenue R billion	% of revenue	Cost per kWh
Distributors	802	89 718	42,47%	73 009	40,95%	0,81
Residential	5 838 754	11 863	5,62%	14 070	7,89%	1,19
Commercial	50 956	10 339	4,89%	11 279	6,33%	1,9
Industrial	2706	48 295	22,86%	32 701	18,34%	0,68
Mining	1012	30 559	14,46%	25 915	14,53%	0,85
Agricultural	81 806	5405	2,56%	7659	4,30%	1,42
Rail	510	2849	1,35%	2990	1,68%	1,05
International	11	15 093	7,14%	10 682	5,99%	0,71
	Total	**211 272**	**Total**	**178 305**	**Mean**	**0,84**

Table 1: Summary of Eskom customer information sheet. (Source: Eskom Integrated Report, 31 March 2017).

The quick analysis shows that this is not the case and to further justify the statement, one simply has to compare the difference between regular Megaflex and the local authority Megaflex tariffs – there are virtually no differences, perhaps two cents' difference in the energy rates and virtually no differences in service and network charges.

Eskom supplies 51,7% of its total energy to its South African electricity customers, representing about 40% of the South African customer base. Exports account for 7,14% of sales and the remaining 42,4% of the energy is sold to municipal distributors who then on-sell to the 60% balance of the South African customer base within the municipal distribution areas [4].

In reality municipal distributors are Eskom's "prime" Megaflex retail customers, by far the biggest customer group in terms of sales volumes and from whom a relatively high margin is extracted, owing to the fact that their load profiles are characterised by a greater proportion of expensive morning and evening peak energy sales. At 81 cents per kWh, the cost is significantly more than the 68 cents for their flatter load profile industrial Megaflex customers.

Parliament expects municipal electricity prices to be competitive to those of Eskom, however the point is never made that 60% of the country's electricity consumers and therefore 60% of the final distribution assets that need to be maintained, are not in Eskom's hands. The cost of building and maintaining these assets and the need to create a surplus (a return on assets) for the municipality has to be factored in on top of this and means that municipal tariffs will never be able to compete with those of Eskom. The big disruption is that industry and commerce, being "business orientated", migrate out of municipal supply areas to Eskom supply areas. They are also not inclined to establish new businesses in municipal areas. These anomalies indicate that there are serious structural problems with the industry.

One of the main reasons that large corporate company headquarters are moving out of City Power commercial precincts like Rosebank and into Sandton, which is Eskom supplied, is that, over a year, the energy cost per square metre of office space is significantly lower. There is no corresponding migration of low income residential areas into Eskom supply areas, and definitely no rush on the part of Eskom to electrify and provide service to low income settlements in municipal supply areas where a massive cross-subsidy from the commercial and industrial sector would be required to service them.

Further evidence of this disruption is that recently, certain municipalities have been unable to pay their Eskom bills – in particular, those that have a predominantly residential customer base without a balancing portion of commercial and industrial customers to provide the necessary cross-subsidy to keep residential tariffs at an affordable rate. The eventual result is either higher residential tariffs with massively disruptive runaway non-technical losses or worse, loss-making residential tariffs to start off with. Both lead to an inability to pay Eskom.

To effect "credit control" to fix the problem, Eskom nowadays requires defaulting municipalities to sign a new supply agreement and to lodge a "consumption deposit" with them in case of payment default. Definitely no consideration here that these defaulting municipal distributors are no different to Eskom distribution operations in Soweto for example, where losses are also high and the trend is proving difficult to reverse [4].

Note in Table 1 that Eskom also has over 5-million residential customers, largely in the low income sector. These customers are also being cross-subsidised from other tariff categories, and yes, you guessed it, the biggest contribution to their revenue, at 40,9% of the total, comes from the distributor customer category. Not only are we cross-subsidising our own low income residential sector, we are also making a contribution to Eskom's low income sector's subsidy. This is not sustainable.

The final point to be made here is that both Eskom and municipalities are state owned entities. The unsustainable structure of the industry will inevitably lead to the need for government to bail one or both of them out. Could this be a disruption for Treasury perhaps?

Regulatory frameworks

Around the world, regulatory frameworks do tend to lag industry developments but are eventually formulated and put into effect. Regulatory changes around the world have largely moved towards de-regulation in order to introduce competition through IPPs and allow market forces to drive industry evolution. As it is for market reform, our disruption comes from delays in getting sensible regulations in place.

The first regulatory guideline for SSEG was issued by NERSA in September 2011. Controversy followed, with the argument that the document was in conflict with the Electricity Regulation Act 2006. Public hearings were conducted in 2014, and since then, the industry has been reassured by the DoE that the matter would be resolved within a month or two. The draft regulations clarify the activities that require only registration rather than licensing and are enabling in that they will bring an element of de-regulation to the small scale power generation market.

If only for the purpose of clarifying the situation from a safety perspective, virtually all municipalities are looking forward to the final gazetting of the new regulations. Something is, however, disrupting the process, despite NERSA approving pilot SSEG tariffs for several municipalities. The industry is being pushed towards working under the radar by these delays, in effect developing in an uncontrolled and unregulated manner.

The draft Regulatory Rules on Third Party Transportation of Energy was first published in March 2012. Having been written from the perspective of a vertically integrated utility, the regulations were naturally acceptable to Eskom but still do not have the approval of the municipal distributors. Workshops and public hearings were conducted in 2014 and 2015 where the objections were clearly tabled, but no real progress has since been made.

There are fundamental principle issues with the regulations, related to the distorted structure of the industry. One fundamental regulatory principle is that both loads and generators must pay to access the networks. As for as municipalities are concerned, Eskom is a generator. No municipality charges Eskom to use their grids, yet the regulations require that all generators should pay for access to their grids. This means a non-Eskom generator would be disadvantaged in terms of competitiveness.

On top of this issue, a few of the objectionable clauses are the following: ERLN (2015)

7.11 Generators connected at Medium Voltage level (11 to 33 kV) shall be assumed to be embedded in demand dominated nodes and shall be exempted from paying DUOS network charges.

6.7 Any load customer shall be free to go into bilateral arrangements with any third-party generator, i.e. non-Municipal and non-Eskom generator.

12.8 If a network operator's performance drops below the 98% and 95% availability limits for Transmission and Distribution Systems, respectively, then the network operators should compensate the generator for energy that could have been exported into the system at WEPS rate.

The worst case scenario of this is where one of a municipal distributor's existing customers enters into a bi-lateral agreement with a generator that connects to the same grid at 11 kV. Energy sales revenue is lost as the customer no longer purchases all their energy from the distributor. The loss is not offset by new network charges from the generator as there is an exemption if these are connected at 11 kV or below, which by its very nature will be the case for embedded generation. On top of this, if the network is vandalised, the distributor must compensate the generator, who makes absolutely no contribution to the system, for any lost generation. We would be foolish to allow this disruption to creep into our industry.

A fresh look at these regulations is needed. One option is to change the principles so that all loads continue to pay for network access and generators intending to enter bi-lateral agreements with private off-takers must also pay network charges. Any generator willing to sell power to the distributor for the purpose on on-selling to the distributor's customers should be allowed free access to the grid, as is the case with Eskom power. The network charges to generators should also be time related, as any generator putting power into the municipal grid during peak periods is really doing the municipal distributor a favour. Concessions should be made to reduce (or even incentivise) network charges for distributed generation that makes a contribution behind the Eskom meter at the right time of the day.

New options and competitors

Shopping centres have fast realised that there is a good correlation between the output of a rooftop PV system and their air conditioning load. The correlation means that there is never a surplus that is fed back to the grid and there is a very strong argument that such an installation can always be classed as "own use" and will not require a generation license. Any commercial building dependent on air conditioning will present the same scenario. The levelised cost of rooftop PV systems has long passed the parity point with respect to municipal tariffs and are fast approaching the parity point with respect to Eskom bulk tariffs. In municipal areas the business case for PV is positive.

New renewable energy companies, keenly supported by the banks for financing, are offering leases to businesses with rooftop space for PV systems. The lease takes more the form of a PPA, with only CPI increases applied over the next 15 years – an obvious, low risk choice for any business with air conditioning load. The big question to ask is why municipal distributors are not already doing this for their own customers. These are truly our new competitors.

A revelation from City Power's 2014 cost of supply study is that it costs R893 per month to maintain the grid to residential customers; the figure applicable to low income as well as mid to upper income sectors. This amounts to over R10 000 per annum. A 20 A service connection in a low income area costs R24 000 to install, including the bulk supply contribution. It is required that "regularised" informal settlements now be provided with grid services. To make such a grid based energy system work, City Power needs to subsidise the basic energy for these communities and will have to source the necessary energy from Eskom forever, at an ever increasing cost.

If a five year time frame is considered, a subsidy of over R75 000 per household is extracted from the commercial and industrial tariffs to provide the service connection, before a single kilowatt-hour is delivered to the household. Is it possible to provide a PV system to meet the household's electrical needs for public lighting, indoor lighting, cell-phone charging, internet or TV access and perhaps refrigeration, together with a bottled gas system for the household's cooking requirements for the same amount of money? Is it possible that such a system could be built to last ten years and come in at half the cost?

It seems feasible and new cheaper over-time options may well be available to municipal distributors. A potential problem may be to convince these customers of the value of receiving such "sustainable utility services" rather than the grid.

Skills and diversity

If a "back to basics" approach is taken towards ensuring the skills the industry needs are developed, technology advancements have raised the baseline of what "basic" means. Today, the basic skills required in the secondary plant areas of the distribution industry including the disciplines of metering, numerical protection, SCADA and energy management requires a new breed of serviceman, capable of dealing with the digital aspects of the business, electronic communication systems as well as the primary distribution plant. This is particularly true if the distributor has any "smart grid" ambitions, and the skill set will need to include the ability to support the integration of information systems at a higher level.

The younger set that have mastered all of these disciplines are sought after resources in private industry and it is difficult to keep them in the municipal environment. Much of the engineering work force with deep primary plant knowledge and experience, who have also learnt the new digital aspects "the hard way" are on the verge of retirement. While newly qualified engineers are conversant with digital systems as the subjects are included in their university curricula, the problem is that there are just too few of them.

By contrast, there seems to be a fair amount of digitally competent people in the ICT sector, many looking for employment. Perhaps a way to deal with the issue is to design bridging courses to up-skill ICT competent staff with basic distribution engineering capacity. A modern substation is a microcosm of the ICT world, ideally suited to this kind of person, provided they understand the risks of the substation environment.

Conclusion

There are at present many disruptive factors affecting our industry, but by far the most severe is our tarnished image and our loss of credibility, brought about through graft and corruption within government and at all management levels, from board members to executives, from senior operational management down to the procurement officers and clerks of works. Abundant evidence of this has emerged in recent months and despite virtually none of the evidence being refuted, there has been very little action taken against perpetrators by the relevant authorities.

The slow pace of EDI transformation in South Africa, leading to an increasingly unsustainable industry, has itself been a disruptive factor and, if allowed to continue, has the potential to eventually collapse the industry in one final mega-disruption where it will fall on the state to bail out Eskom and the municipal distributors alike.

One positive note to consider is that the South African EDI may have the chance to leap-frog some of the transition pains that other parts of the world have already been through. The time is ripe for bold but carefully considered, decisive action is to be taken. This needs to happen soon, before we finally reach a final sustainability limit which this author believes may only be a few years away.

References

[1] FP Sioshansi (2017): "Energy storage: The next game changer" EEInformer 27(9): 3-6.

[2] Wise minds: "The energy transition and large utilities (2017). Available from: www.forumforthefuture.org/sites/default/files/files/WiseMinds_Report_FINAL_compressed.pdf (Accessed 4 September 2017).

[3] W De Beer: (2016) "Maintenance backlog impact on service delivery", EE Publishers. Available from: www.ee.co.za/article/distribution-infrastructure-maintenance-backlog-impact-service-delivery.html (Accessed 1 September 2017).

[4] Eskom Integrated results (2017): Available from: www.eskom.co.za/IR2017/Pages/default.aspx (Accessed 5 September 2017).

[5] ERLN: "Regulatory rules for network charges for third party transportation of Energy". Feedback to SEA-SALGA-SACN urban energy network (2015). Available from: www.erln.org.za/images/jevents/55c1c0bfd38041.95206450.pdf (Accessed 4 September 2017).

[6] The Energy Transition: "Resist? Or Embrace?" Energy Research Centre, UCT. Presentation at SALGA Metro engagement on Electricity and Energy, Cape Town, August 2017.

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Second generation solar street lighting: Technology evolution and applications

by Olivier Saint Girons, Sunna Design

Lighting is an essential driver of socio-economic growth. It creates the conditions of road and people safety and security while increasing the potential for economic and social activities. With the rise of solar and LED technologies, strong technical evolutions have appeared in the field of solar street lighting.

These technological innovations include ten-year lifespan batteries, smart battery and lighting management systems (such as no black-out function), anti-theft features and easy plug-and-play installation.

This evolution is a real game-changer for many public and private applications as solar powered street lighting becomes a viable option.

The market uptake of these products will contribute towards a more sustainable and smart city with solar powered products, lower greenhouse gas emissions and enhanced connectivity.

We will first introduce the technology evolutions of solar street lights. Then we will discuss the applications of these products and present a case study.

Evolution of solar street light technologies

First designs and drivers of change

Off-grid solar systems such as solar street lights have been designed and available on the market for more than 40 years. However, their price and performance highly limited their market uptake.

First generation solar street lights were made of conventional solar panels on top of a pole associated with a lead-acid battery, either buried, at the bottom or on top of the mast (see Fig. 1), a charge controller and a lantern.

The main technical issues with first generation solar street lights are the low lifespan of lead-acid batteries (a few months to two years under high temperatures such as in Africa), the low lighting performance, the occurrence of black-outs and their vulnerability to theft.

In the past ten to 15 years, a number of key drivers have changed:

- The price of solar panels and solar systems has been divided by ten, making it one of the most competitive energy sources available on earth.
- The yields of solar panels (energy output per meter square of panels) have increased significantly.
- The cost and performance of batteries have improved.
- LED (light-emitting diodes) lights have shown highly dynamic developments: high lumen efficiency (>150 lm/W), directionality and reduced light pollution, long lifespan (50000 hours), superior quality of light (high CRI) and extended controllability.

Building upon those changes, a number of research centres and companies have come up with new designs and technologies for solar street lights, thus solving some of the main issues associated with previous technologies.

All-in-one solar street lights

Through heavy investment in research and development, companies like Sunna Design have changed completely the design and technology of solar street lights by creating integrated solar street lights (ISSL) with second generation technologies.

These ISSLs are specifically designed to resist high temperature in tropical and sub-tropical climates, to offer a ten year lifespan without technical maintenance, and to be less susceptible to theft.

In terms of design, an ISSL encapsulates all components of the street lights in a single cover located in top of the lighting pole (see Fig. 2).

This evolution is mostly enabled by the use of batteries which work with high depth of discharge and are much smaller and lighter, as well as by the use of a smart battery management system.

Batteries and smart battery management systems

In the all solar streetlight systems, the battery is the critical point, because it is very heat-sensitive and often causes system failures. The most important selection criteria are daily cycling, resistance and performance under very high temperatures, maintenance and lifespan.

In the African climate and for solar street light applications, the optimal technology is the nickel-metal hydride technology (NiMH), compared to lead-acid and lithium-ion

Fig. 1: The battery is placed either at the top of the mast, at the bottom or is buried.

Fig. 2: Design of an ISSL.

batteries. Table 1 provides is a description of these three battery technologies.

Lead-acid batteries (also called VRLA, AGM or gel) are the oldest rechargeable storage technology. Because of their cost-effectiveness and availability, lead-acid batteries are the easiest and cheapest choice for many applications. But they show limited service life when submitted to both high temperature and deep cycling. Although they are widely used for solar applications, there are no smart energy management systems to prevent blackouts, and high temperature still involves a limited lifespan inducing regular technical maintenance (battery replacement). It is often the cheapest upfront solution but this technology isn't well suited to street lighting application, especially in hot areas, thus leading to very high operating costs.

The lithium-ion batteries represent a comparatively new technology without memory effect. Among them, a large scale of technologies has been developed: lithium-ion-phosphate (LFP), lithium-manganese spinel (LMO), lithium titanate (LTO), lithium-nickel-manganese-cobalt (NMC) and lithium-nickel-cobalt-aluminum (NCA). The variety of the options makes it very complicated to make sure that the right battery is available and used for the right application.

The most popular technology on the solar street light market is lithium-ion phosphate (LiFePO4). This technology has currently the same main weakness as lead-acid batteries as they show limited service life when submitted to high temperature or deep cycling.

Nickel-metal hydride batteries have become very popular over the last decade, especially for industrial applications such as power tools or hybrid vehicle applications. There have been many successful improvements of the NiMH battery performances through efforts made on hydrogen storage alloys to achieve higher energy density, faster activation, better rate capability and lower cost.

NiMH offers reasonable specific energy and covers one of the largest temperature ranges that available rechargeable battery technologies can afford (-40°C to +80°C) nowadays. This maintenance-free technology integrates a safety valve in case of cell temperature increase and shows very good thermal properties without memory effect. The issue with NiMH is often the initial cost of purchase, but its resistance to heat and deep cycling leads to an incomparable lifespan, making the total cost of ownership lower than with any other battery technologies.

The battery management system (BMS) is at the heart of a solar streetlighting system: it manages the energy production from the solar panel, the charge of the battery and controls lighting levels.

New BMS technologies by now offer a higher level of intelligence with adaptive lighting profiles based on the weather and state of charge of the battery, no blackout features, battery life extension mode and connectivity features. These smart electronics allow the lighting service to last all night long without interruption and enhance battery lifespan.

	Lead-acid battery	VRLA	Lithium battery	LiFePO4	NiMH battery
Temperature range	-20°C/+50°C		-20°C/+60°C		-40°C/+80°C
Lifespan at 60% DoD (C10-20°C)	800 cycles (2 years)		1500 cycles (4 years)		5500 cycles (15 years)
Lifespan at 60% DoD (C10-40°C)	480 cycles (1,3 years)		900 cycles (2 years)		4000 cycles (11 years)
Replacement of the battery over 10 years	six times minimum		three times minimum		None

Table 1: Battery technology comparison chart.

Capital requirements	On-grid 140 W streetlight	Solar streetlight
Lantern	R5800,00	R42 050,00
8 m pole	R2900,00	R2 900,00
Civil work	R26 100,00	R1 740,00
Installation and commissioning	R4350,00	R2 900,00
Total purchase cost (per unit)	R39 150,00	R49 590,00
Total capital investment required	R19 575 000,00	R24 795 000,00
Net investment requirement	**R0,00**	**R5 220 000,00**
Direct electrical cost		
Electrical load of lamps	70 000 W	-
Driver loss (10% of electrical load)	7 000 W	-
Total electrical load	77 000 W	-
Running time per year	4380 hours	4380 hours
Energy consumed per year	337 260 kWh	-
Electrical demand savings	-	337 260 kWh
Total cost of electricity / kWh	R0,75	
Total cost of energy (per year)	R252 945,00	R0,00
Direct electrical savings (per year)	**R0,00**	**R252 945,00**
Maintenance		
Maintenance cost including clean-up, lamp, ballast, ignitor & capacitor replacement for on-grid lights (per year)	R1 880 287,50	R343 650,00
Maintenance savings	**R0,00**	**R1 536 637,50**
Return on investment results		
Total operating cost (per year)	R2 133 232,50	R343 650,00
Total savings on the first year	**R0,00**	**R1 789 582,50**
Electrical and maintenance savings		
Payback period	**n/a**	**2,9 years**

Table 2: Case study of a 15 km road – 500 solar lights – grid street light cost vs ISSL costs.

Applications and reference cases

Applications

Integrated solar street lights with NiMH batteries and smart management systems are a game changer for many lighting projects.

Although the capital expenditure to purchase the lights is higher than with conventional street lights (such as HPS or LEDs), ISSL presents a number of cost advantages:

- No cost for digging trenches, including equipment and labour.
- No cost for underground wire (no cabling is involved), distribution and control panel.
- No cost for electrical installation and connection fees.
- No electric usage and demand charges: ISSL provides 100% energy savings over conventional road lights, and hence savings on the energy bill of municipalities or end-users.
- Reduced maintenance cost thanks to long-life components.

Solar streetlight systems are therefore ideal for a number of applications:

- New developments where the availability, cost or timeline of new power supply is an issue.
- Existing locations where the cost or technical difficulty of digging trenches is too high.
- Locations where electricity costs are high.
- Remote areas – rural development lighting projects.
- Eco-sensitive landscapes.
- Temporary or emergency installations.

Also, solar street lights can help municipalities and public entities fulfill at an optimal cost some of their socio-economic and environmental commitments:

- In many rural areas, solar streetlights provide the only source of light. When situated in an offgrid community centre or road, solar streetlights provide security, help lengthen the work day, support increased economic activities, community interaction, and education-related activities.
- As part of their climate change mitigation strategies, more and more municipalities and utilities are now setting targets for greenhouse gas mitigation and energy generation from renewable sources. Solar streetlights can be a good way for countries/utilities to meet both these targets. Installation of solar streetlights can count as solar power generation, and a switch to solar streetlights helps reduce GHG emissions significantly.

Fig. 3: Installations in Nigeria (left), Ivory Coast and South Africa.

Case study and references

Table 2 presents the case study of a 15 km road lighting project in Nigeria with cost comparison between grid and solar street lights.

The case study demonstrates a pay-back period of three years while not taking into account the environmental benefits of the project. In that specific case in Nigeria, the total cost of ownership for the municipality was lower than with other options.

The market for integrated solar street lights is increasing rapidly. The market is particularly active in Africa – with high volumes in North Africa, West Africa (the biggest market being the public market in Nigeria) and East Africa.

South Africa and its neighbouring countries see an increasing number of installations, from public street lighting to mining, industries or private estate lighting.

For further information about South African references please contact the author.

Conclusions

Second generation solar street lights open new opportunities in terms of public lighting, especially in Africa.

While the initial technology had important limitations, integrated solar street lights with NiMH technology are a complete game-changer. Their lifespan has reached ten years hot climates. Their yields and performance have increased dramatically.

They become a viable option in terms of total cost of ownership in many applications and they open the way to important changes in lighting business models for municipalities with possible financing of capital costs and very low operating costs, especially no electricity consumption and little maintenance.

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Innovative technology permits predictive maintenance on an HV power network

by Patrick O'Halloran, City Power

This paper covers innovative technologies that permits predictive maintenance to be done on a high voltage power network. Results obtained from performing condition monitoring testing on high voltage equipment have prevented numerous failures. Many of these failures would have occurred and caused extensive and extended outages in Johannesburg.

City Power and Singapore Power Global Solutions entered into a strategic partnership that is now bearing fruit. Singapore Power Global Solutions is the consulting division of Singapore Power responsible for ensuring that electrical utilities can implement condition monitoring to improve the reliability and quality of supply to their customers.

Singapore Power has successfully implemented condition monitoring over the past 20 years. Condition monitoring is one of the key contributing factors for Singapore Power becoming one of the most reliable utilities in the world. Based on the latest performance indices, a customer in Singapore would experience a power failure only once in every 142 years (System Average Interruption Frequency Index – SAIFI) and the longest fault any customer would experience is roughly 30 seconds (System Average Interruption Duration Index – SAIDI). These figures are absolutely amazing, but possible (see Figs. 1 and 2).

Benefits of performing condition monitoring

When condition monitoring testing is implemented, the following benefits shall be achieved:

- Improved reliability and quality of supply due to reduced faults and forced outages (improved SAIDI, CAIFI and NRS 048, etc.).
- The root cause of the partial discharge is not destroyed and preventive maintenance can be done before failures occur. Rectification costs prior to a failure are much cheaper than repair cost after a failure.
- Extend intrusive maintenance intervals and perform condition based maintenance only
- Extended equipment life

Road map to make condition monitoring a success

Due to the nature of electrical networks, faults will still occur and because of this a business needs to contain the fault and prevent any unnecessary upstream trips. Once a fault has been cleared it is essential to get to the root cause of the failure. Once this is known, condition monitoring programs may need to be changed to detect such faults in the future before they occur. Quality assurance is critical to eliminate installation errors. Lastly, when a certain product has reached its end of life, it should be replaced before it fails.

Fig. 3 shows Singapore's recommended condition monitoring road map.

Root cause of equipment failures

Partial discharge (PD) is the root cause of most HV and MV network related failures experienced by City Power, excluding

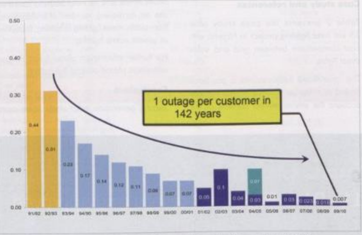

Fig. 1: Singapore Power System Average Interruption Frequency Index (SAIFI).

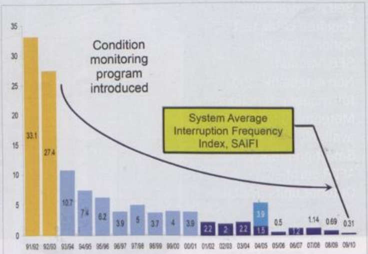

Fig. 2: Singapore Power System Average Interruption Duration Index (SAIDI).

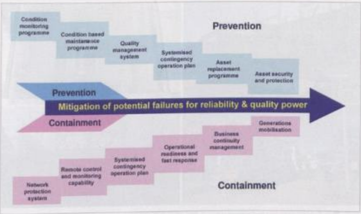

Fig. 3: Singapore's condition monitoring road map.

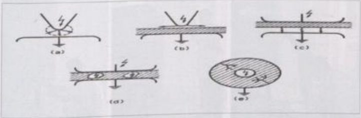

Fig. 4: Various partial discharges: (a) corona discharges, (b) and (c) surface discharges, (d) and (e) cavity discharges.

Fig. 5: CBI's EHV/HV test trailer testing 275 kV and 132 kV cable terminations at Sebenza SS.

Condition monitoring system	What they detect	Applied to
Thermal scanning	Overheating	Equipment
Dissolve gas analyst	Abnormal oil contents	Equipment and cables
Oil pressure monitoring	Low pressure	Cables
Distributed temperature sensing	Hot spots	Cables
Very low frequency test	Low insulation	Cables
Partial discharge monitoring	Minute current leakage	Equipment and cables
Operating mechanism monitoring	Abnormal operation	Equipment

Table 1: Summary of possible condition monitoring systems that can be applied.

vandalism and theft. Once PD has begun it will always worsen, leading to insulation breakdown equipment failure. It is therefore imperative that once PD is detected, it is rectified before the failure occurs.

PD is defined as a localised discharge process in which the distance between two electrodes is partially bridged. PDs may originate directly at one of the electrodes or occur in a void or cavity inside the dielectric. (See Fig. 4a, b and c.)

The various types of partial discharge are outlined below:

- *Corona discharges*: occur as a result of a non uniform field on sharp edges of a conductor subjected to high voltages.
- *Surface discharges*: occur on the surface of the different dielectric material.
- *Cavity discharges*: occur when cavities are formed in solid or liquid insulating materials where the gas in the cavity is overstressed and discharges occur.

PD is a result of many contributing factors including:

- Poor workmanship (clearances, installation errors and lack of skills)
- Incorrect application of products (technology changes)
- Overload leading to insulation breakdown (heat causes insulation to breakdown)
- Manufacturing defects
- Equipment designs

Once the PD causes the insulation medium to breakdown, a power flashover will occur. This PD can be detected and assessed, but the exact failure time can't be predicted.

The recommended Singapore condition monitoring test equipment and techniques are able to detect potential faults on equipment before a failure occurs. As these potential faults are detected before a failure occurs, their location and root cause can be identified and rectified before they fail. This then ensures safety of staff and communities by preventing potentially dangerous failures. The reliability and quality of supply is improved every time we prevent a failure which would normally result in customer outages and voltage dips. City Power is able to carry out pro-active condition-based maintenance on the network and is moving away from current time-based maintenance practices, which have in the past missed many potential faults. City Power in the future would only shutdown the power plant if it is absolutely necessary to perform preventative maintenance. City Power has already saved lots of money on maintenance and post failure repair costs. One day power interruptions should be reduced to hopefully only vandalism and theft related failures.

The following non-intrusive online condition monitoring testing techniques should be implemented to best determine the operating condition of assets:

- Ultrasonic
- Transient earth voltages (TEV)
- Radio frequency (RF)
- Inductive coupling frequency response via high frequency current transformers (HFCT)
- Capacitive coupling frequency response
- Dissolved gas analysis (DGA)
- Infrared
- Leakage current measurements

It is now possible to detect insulation problems in cables, overhead transmission lines, power transformers, switchgears, and other electrical equipment in our power electrical networks. Condition monitoring testing shall become part of everyday business within City Power and not a special once off project (see Table 1).

Due to the nature of insulation systems, online PD testing will give you a good indication that there is a problem, but it will not always give you the exact location of the PD source, especially in cable networks. Online PD measurements are also at Uo system voltage. The best way to test the actual condition of any insulation system is with offline testing, where an overvoltage is applied, for example 3 x U_o.

Until recently no portable on site HV and EHV testing equipment was available in South Africa. This has now changed and both HV and EHV cables and power transformers can be tested on site at suitable high over voltages (see Figs. 5 and 6).

Simple way to perform condition monitoring testing

Fig. 7 outlines the simple steps to test a transformer cable box, but the same test will be done on all MV switchgear.

Infrared thermal scanning of all equipment has evolved and can even be done with certain smart phones. This condition monitoring technique is cheap and very effective for detecting differences in temperatures during operating conditions (see Fig. 8).

PD in medium voltage switchgear is measurable in two different ways with EA Technology UltraTEV Plus[2] handheld instruments:

- Capacitive probe for the detection of TEVs in the VHF electromagnetic spectrum (3 – 80 MHz).
  - Internal discharge
  - High level surface discharge to earth

Fig. 6: MR's EHV/HV test trailer testing a 250 MVA 275/88 kV power transformer at Delta SS.

TEV PD Test	Infrared test	Ultrasonic test

Fig. 7: Singapore technical staff performing PD testing on a transformer cable box.

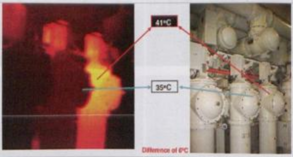

Fig. 8: Infrared thermal image of GIS switchgear clearly shows a difference in temperature.

Fig. 9: EA Technologies UltraTEV Plus handheld PD tester unit.

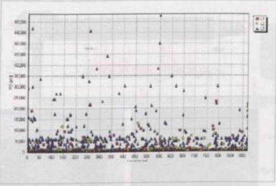

Fig. 10: SEBA OWTS PD test on a PILC MV cable – PD scattered and difficult to analyse.

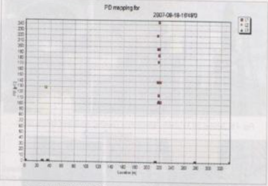

Fig. 12: SEBA OWTS PD test on a XLPE MV cable after first joint was removed out of the circuit.

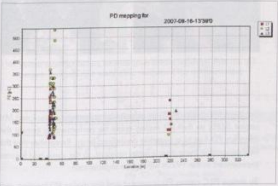

Fig. 11: SEBA OWTS PD test on a XLPE MV cable – PD scattered and simple to analyse.

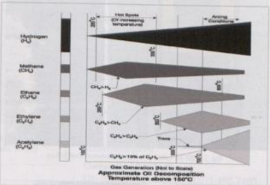

Fig. 13: DGA interpretation to identify potential internal fault.

- Ultrasonic airborne microphone or contact probe generally centred at 40 kHz.
  - Surface discharge.

The latest UltraTEV Plus[2] unit offers so much more than a measurement value which can be confused with background noise or corona. The new unit automatically diagnoses the measurements and confirms if it is PD or noise from a loose plate, etc. (see Fig. 9).

The highest failure rates in City Power are from cable termination and joint failures. The reason for these failures has a lot to do with the jointer's skills. In City Power we subcontract lots of work to contractors and to ensure they perform the joint or termination you need to perform the correct test which will confirm the quality of the workmanship.

In the past, City Power has done typical SANS 10198-13 recommended commissioning tests which include over voltage pressure testing which are "go" or "no go" tests. This has proven not to be adequate as a poorly installed joint may withstand the applied voltage pressure test but if PD is present a fault occurs after a certain time period because the PD eventually weakens the insulation which leads to a failure. It must be remembered that all insulation ages, and it is important for us to monitor and know the condition of the insulation to prevent failures.

Cable testing with DC voltage has also proven to be unable to detect potential faults in joints, terminations and cables, unless they are bad faults. The use of AC voltage test equipment is a must to ensure we test the permittivity of insulation materials which is what all equipment will experience when energised.

Singapore Power now PD tests all new XLPE cable systems to detect any unacceptable PD activity in joints and terminations. This detected PD over time breaks down the insulation if not corrected immediately. The days of only performing a "go" or "no go" pressure test to prove the reliability of the cable are over. It is now time to record finger prints of MV cable networks and then monitor them over their life cycle to ensure reliability of supply.

If PD is detected during testing, the system cable system should not be energised, but investigated.

City Power have now changed from paper

Fig. 14: Typical on-line DGA monitor installed on a power transformer.

Fig. 15: Typical 88 kV cable termination (sealing end) and failure point.

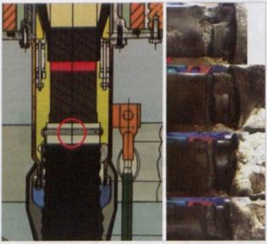

Fig. 16: 88 kV cable termination international failure point after PD has occurred.

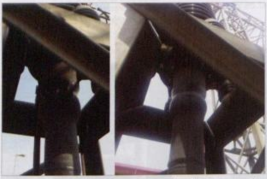

Fig. 17: Heat shrink sheath does not seal correctly and moisture enters the termination at the critical main earthing point.

Fig. 18: Epoxy resin that is damaged due to the moisture ingress. The epoxy resin protects the main earth from moisture.

Fig. 19: Single point bonded HV cable system.

Fig. 20: XLPE insulation eroded away from the partial discharge activity. HV cable insulation will breakdown under these high electrical stresses.

insulated MV cable (PILC) to crosslinked polyethylene insulated MV cables (XLPE) so that PD testing cable be performed to ensure the joints are PD-free to acceptable predefined limits. Remember that the new generation these days is water resistant, so the same bad failures experienced in the 1970s will not be experienced.

By design PILC cables PD is present and this makes PD location very difficult (see Figs. 10, 11 and 12).

Dissolved gas analysis (DGA) is a very important condition monitoring test for power transformers. City Power has been doing DGA tests for 15 years already and we are able to analyse the results in our own laboratory. When analysing the GDA results for a specific transformer the data needs to be trended to ensure correct analysis is done and correct decisions are made with regards to these critical assets (see Fig. 13).

City Power has installed on-line transformers 9 Gas DGA monitors. On-line transformers 9 Gas DGA monitors are a must for all of City Power's new power transformers (see Fig. 14).

88 kV termination failure case study

Over the last few years City Power has experienced numerous 88 kV cable termination failures at two specific substations. After detailed investigations and field testing with the OEM who designed, manufactured, supplied and installed the 88 kV terminations the root cause was identified (see Fig. 15).

The failure mode identified was moisture ingress into the critical earthing connection point of the termination. At this point the CSA and tin copper earth braids are connected via a wiped connection. Due to the design and the ingress of moisture, the aluminium sheath corroded away and the main earth was no longer effectively earthed (see Figs. 16, 17 and 18).

Due to the single earthing system applied, the sheath of the 88 kV was now not clamped to 0 V (ground potential). All four inspected terminations failed at the same location way below the stress control cone. The OEM recommended simple offline ductor testing (see Figs. 19 and 20).

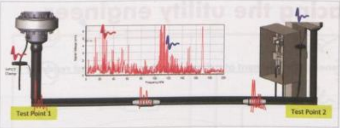

Fig. 21: Online testing of 88 kV cable termination and cable.

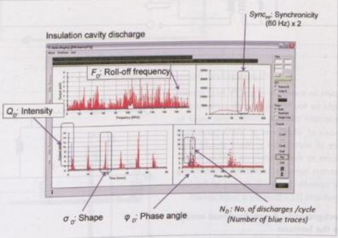

Fig. 22: Online testing results.

City Power have roughly 350 88 kV terminations of the same design. Although this simple offline ductor test is extremely reliable and repeatable, outages are not always possible. City Power worked with MARTEC who have specialised online testing techniques to test and establish the unique PD pattern for the failure mode that had been identified. The PD failure mode was previously eliminated as corona when in fact it was partial arcing at the main earth contact (see Figs. 21 and 22).

Conclusion

The vision of City Power's management is commendable to strategically partner with Singapore Power who is one of the world's most reliable electricity utilities to make a step difference with regards to preventing potential failures and also improving the reliability of supply to end customers.

The results obtained from performing condition monitoring testing have prevented many failures. Many of these failures would have caused extended outages across the city of Johannesburg.

Regional condition monitoring interest groups need to be established to share all PD findings and to teach interested engineers how to test and what to look for during inspections. Many failures can be prevented once such interest groups are proactively interacting and producing national recommendations.

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New challenges facing the utility engineer

by Paul Gerber, Nelson Mandela Bay Municipality

Utility engineers are in a quickly changing energy environment at a time when they are the least ready for it.

The new environment is characterised, inter alia, by:

- Less revenue.
- Less skilled and experienced human resources.
- Restricted access to other resources (e.g. latest design software) as a result of tighter budgets.
- Bi-directional power flows.
- The possibility of small scale embedded generators (SSEGs), with its associated protection and safety risks, anywhere on the system.
- The harmonic pollution of the system by modern electronically controlled devices and the interaction between devices.

The most significant change in the industry has likely been introduced by small scale embedded generators – whether grid connected or not. The utility is suddenly confronted by new challenges in terms of safety, earthing, protection, harmonics and more. Islanding needs to be detected and SSEGs must be isolated from the grid within two seconds. Basic and/or passive islanding detection devices might not be able to do so under generation/load matching scenarios, necessitating the need to insist on a certain level of device. It becomes even more essential to do so, bearing in mind this device actually becomes your protection system in scenarios where PV fault current might be too low to operate conventional protection devices. Utilities also need to decide at what level of SSEG generation (size of installation in Watt) should have access to the inverters of SSEGs, as the inverters have the capability of controlling the complex power, S, in any of the four quadrants [1] – possibly a huge benefit.

Abbreviations	
CARD	NMBM developed (D. Michie) design software used for LV reticulation designs
CDU	Consumer distribution unit
GPR	Ground potential rise of earth mats/earthing systems
NMBM	Nelson Mandela Bay Municipality – Electricity & Energy Directorate
PCC	Point of common coupling
PV, PV installation	The complete installation comprising PV arrays, inverter and filter
SSEG	Small scale embedded Generator
TOU	Time of Use
Utility engineer	A technically skilled person responsible for the design, maintenance and/or operation of a utility's electrical infrastructure

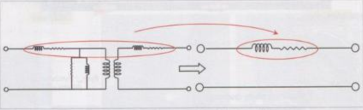


Fig. 1: Reduced (approximate) transformer model.

Background - A new business model on the horizon

A new business model for the electricity business in utilities could take on various forms, but it is a fact that the industry will see change, and that a few elements will likely manifest in any form of a new model:

- Revenue based on kWH sales is no longer a sufficiently accurate way of accounting for the costs associated with the network;
- Tariffs will have to be based on real cost, inclusive of "standby" generation cost when renewable energy is used (to have a sell: buy ratio of 1 : 1 for grid-connected SSEG is clearly unacceptable, as it does not take care of real cost. To do the same split using TOU-based tariffs offers an improvement, yet is still unacceptable from a real cost view point).
- The utility could increasingly just take on the role of balancing supply and demand.
- The focus will (should) shift from selling kWhs to "hiring out a network" used mainly for "storing electricity" and wheeling electricity from generator (e.g. SSEG) to user.
- Closely related to the previous bullet is the provision of professional advice and expertise by the utility engineer and playing watchdog to ensure a network of good technical standard.

Central to the last three bullets is a well-designed, maintained and operated network that exceeds the basic requirements of service quality and power quality as guided by the NRS specifications and NERSA.

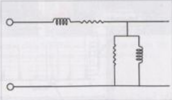


Fig. 2: Model of unloaded transformer.

The new technical challenge – ("problem" statement)

For the utility to remain relevant and financially sustainable, a well-designed, maintained and operated network is not negotiable. Customers would want to remain connected to the grid for purposes such as energy "storage", wheeling and redundancy.

Existing design practices in Nelson Mandela Bay Municipality (NMBM) have fallen into a routine involving verification of only certain basic criteria such as voltage limits, current limits and fault levels. The low voltage (LV) design software (CARD) in use was internally developed and is very basic with an inherent inability to test for the effect of e.g. PV installations, unbalances and harmonics.

Consideration of a wider range of design criteria has become important – more so against a background of modern electronic equipment with higher pollution levels, in particular harmonics.

The designer of LV networks should not have to decide on a set of design criteria each time a small change to the network

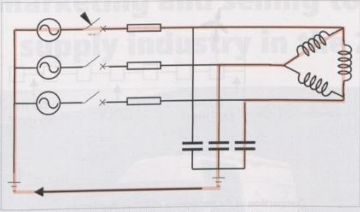
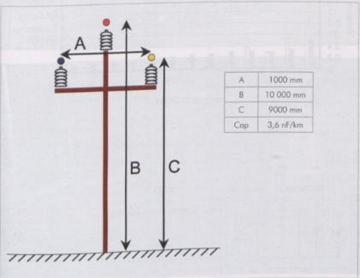


Fig. 3: Possibility of series resonance between an unloaded distribution transformer and system capacitances under un-ganged switching scenarios.

Fig. 4: An example of per phase switching.

Distribution transformer	500 kVA, 11/0,42 kV, Dy11
Xsc	5,42 %
Xi – Magnetising reactance	84 Ω, 238 pu
Ri – Magnetising resistance	242 Ω, 686 pu

Table 1: Parameters of a distribution transformer.



A	1000 mm
B	10 000 mm
C	9000 mm
Cap	3,6 nF/km

Fig. 5: An example of a rural 11 kV line.

(e.g. a small PV installation) takes place. Design criteria needs to be extended and standardised.

Particular technical areas related (but not restricted) to grid-tied SSEGs that need a re-visit (and preferably standardisation), are the following:

- Balancing amongst LV phases and SSEG diversity.
  - Unlike common belief, there seems to be diversity between PV installations using different types of inverters.
  - Re-balancing on older installations comprising breeches joints on paper-insulated LV mains cables may not be straightforward.
- Neutral currents and the capacity of neutral circuits.
- Coupled to the above, the ability of tapered LV feeders to accommodate PV installations at the end of the feeders.
- Harmonic generation and sinking, and in particular, design practices to verify compliance of the same.
- Resonance.
- The possibility of unsafe voltages between the neutral and earth of a SSEG running islanded (off-grid) in SNE reticulation set-ups.
  - Where islanding has been detected and the SSEG is isolated from the grid, the SSEG could continue supplying a house off-grid after a four pole (hence neutral included) change-over switch has been operated as suggested by NRS097. The earth would still be common and connected to the supply point earth mat. A fault there will see the voltage of the earth risen (GPR) in respect to the neutral of the SSEG. This rise (difference) in voltage could be unsafe.

Methodology

The rest of this paper will focus on the following three of the areas mentioned in the previous section:

- Resonance
- Unbalance
- Harmonics

Case studies are done and conclusions drawn.

"Additional" standard design criteria – problem discussion

Resonance

A loaded distribution transformer can, with reasonable accuracy, be presented by its short circuit impedance as indicated in Fig. 1.

However, with the transformer unloaded (or very lightly loaded), the model thereof changes to that in Fig. 2.

This high impedance inductive load could (depending on the primary neutral earthing arrangement) form parallel resonance with the system capacitance. It could also form a series resonant circuit with system capacitances as indicated in Fig. 3 when un-ganged switching takes place [2]. Un-ganged switching happens when links or fuses can be operated per phase – a common phenomena on rural networks (see Fig. 4).

Resonance is not a new phenomena. However, the wider use of SSEGs has increased the chances of unloaded or lightly loaded transformers considerably.

Case study

Assume a distribution transformer with parameters as per Table 1.

Should this transformer be installed at the end of a typical NMBM rural line and it be subject to a Fig. 3 switching scenario (i.e. only the red phase closed), unacceptable resonance starts taking place when the supply capacitance is about 28 nF. At 30 nF, the voltage across two of the transformer's phases would be 14 kV plus – not the ideal. Using a line with the approximate dimensions as displayed in Fig. 5, about 7,5 km of such line will create the "resonant" capacitance.

NMBM has had at least one such incident on its rural network recently.

Unbalance of LV mains feeders

In [3] a tapered feeder similar to the one in Fig. 6 is analysed for the impact of the micro wind turbine installed off CDU 1, nearest to the distribution transformer. This very small, one-off installation of approximately 56% of the After Diversity Maximum Demand (ADMD) can, under certain circumstances, drive the voltage at the distribution transformer's 400 V busbar outside the 10% lower limit, as a result of unbalance and neutral current. The authors concluded that "the utilities cannot ignore their duty to assess network performance, even if a single small generator is added."

SSEG installations complying with the guidelines of NRS 097 do not necessarily guarantee compliance with all design criteria.

Suitable design software is required to perform checks like this.

Harmonics

Harmonics, like resonance, has been highlighted by the increased use of PV installations. It is a well-documented phenomena (e.g. NRS048), but little is said about the way in which it should be designed. Apportioning of harmonics (e.g. per user) is also not widely covered in literature. Once your system is polluted by harmonics, it is difficult to find the origin of it.

When the harmonics generated by PV installations are compared with that generated by other electrical devices and appliances (see Fig. 7), it becomes clear

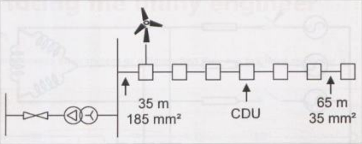


Fig. 6: Tapered LV feeder.

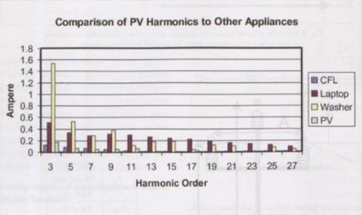


Fig. 7: Comparing PV harmonics with that of other devices.

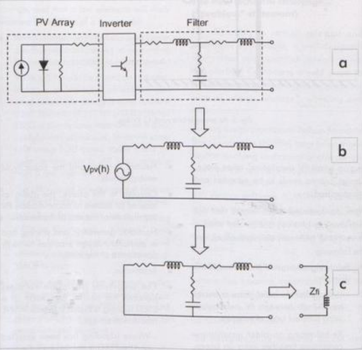


Fig. 8: (a) PV installation; (b) PV installation as harmonic generator; (c) PV installation as a "sink" for other harmonic generators.

Marketing and selling to the electrical supply industry in the 21st century

Long gone are the days that one "made a better mouse trap" and customers flocked to your door. Modern day selling and marketing is multifaceted and one has to be innovative to ensure that your customer and potential customer base is well informed about your offer and is constantly visited and informed of the advantages of your products and solutions.

Traditional ways of reaching the customer by participating in conferences, being affiliate members of electrical associations, distributing catalogues and manuals, with face-to-face visitations has become more difficult. The industry is under pressure with monetary constraints and workload, so time to attend conferences, company visitations and even face-to-face meetings has become restrictive. Literature, social media i.e., twitter, LinkedIn, etc., and even information available on websites or distributed on memory sticks is often insufficient to keep the customer fully informed of the latest products and solutions one has to offer.

Lucy Electric South Africa (LESA) recognised that our customers have very little time on hand to attend face-to-face meetings at their places of work as unexpected call-outs and/or meetings would prevent the prearranged visitation. We decided to invest in a van fitted with fully functional products and mimicked solutions to reach our customers, by being mobile and visit the decision makers wherever they may be, in the field or at office. A hands-on short visit suits the customer.

The van has visited most of AMEU regional meetings since February 2017 and has been as far afield as Namibia to attend the AEDU in Swakopmund.

Our demo van is a great success and provides a much-needed extra selling tool to reach the customer.

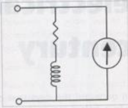


Fig. 9: A household modeled as a harmonic generator.

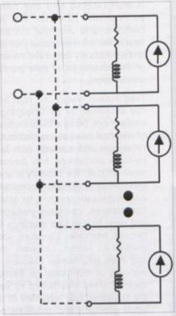


Fig. 11: Multiple households connected to the PCC.

that these harmonics are small compared with the vector sum (per harmonic) of all other harmonics already on the system. For all practical purposes they could be ignored [4].

However, ignoring PV installations as sources of harmonic current, does not mean it can be ignored altogether. It could well play a role in sinking harmonics (hence acting as an impedance) generated elsewhere (in the household by other devices such as laptops).

Fig. 8 shows how a PV installation could be reduced to an equivalent harmonic source (Fig. 8b) and to an equivalent impedance (Fig. 8c), should it be ignored as a source due to its low impact. (Loosely based on [4]).

Fig. 9 reflects a household modeled as a harmonic generator. Should a single household fitted with a single PV installation be connected to the supply system for the purpose of verifying the harmonic pollution of the system, Fig. 10 reflects the model that could be used.

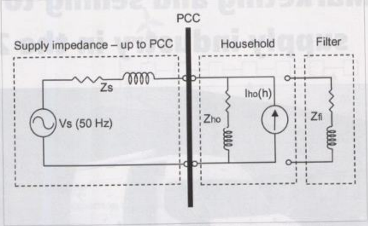


Fig. 10: Household as harmonic generator with PV installation connected to supply.

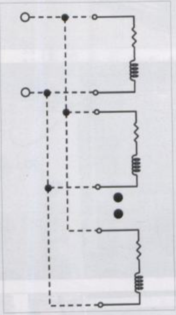


Fig. 12: Multiple PV installations connected to PCC.

where

- V_s = The 50 Hz supply voltage (indicated only for illustration purposes). This voltage needs to be short-circuited when the impact of household harmonics is investigated.
- Z_s = Supply impedance of the grid up to the point of common coupling.
- Z_{ho} = Impedance of one household based on the ADMD and after diversity has been applied.
- Z_{fi} = Equivalent impedance of a PV filter.
- $I_{ho(h)}$ = Vector sum of harmonic currents generated in a household.

The reactance part of all impedances will change with frequency while the resistances of some elements (e.g. cable) will change due to skin effects at higher frequencies.

Figs. 11 and 12 show the revised diagrams for multiple households and PV installations, respectively.

The network parameters are outlined in Table 2.

Harmonic example

It could be seen that there is some resonance at about 4 kHz when the red phase – neutral equivalent impedance – is checked from the PCC. This would have been a concern at lower frequencies where considerable harmonics are injected into the system. However, at 4 kHz virtually no harmonic current is polluted into the system.

If the harmonic currents listed in Table 3 is injected at the PCC in Fig. 15, harmonic voltage distortions at the PCC exceeds the limits of NRS048 for the three highest order frequencies (see Table 4). The harmonic currents in columns 3 and 4 of Table 3 have been arrived at by adding the harmonic current vectors of 2 x CFL tubes, a laptop and a dishwasher as listed in [4], for each of the 20 households. Laptops seem to be one of the worst forms of harmonic generators at higher harmonic orders. Ideally more knowledge is required on the diversity between non-linear loads (harmonic generators) in households. Similar to ADMD and diversity algorithms for 50 Hz analysis, standard algorithms are required for harmonic analysis.

Table 3 also lists the resistance of the LV cable for higher frequencies (column 7) after the skin effect has been accounted

Fault level 11 kV busbar	26 /_ -87° kA
1 φ – E fault 11 kV busbar	2 /_ -20° kA
$R_{supply\ pos\ seq}$	0,0128 Ω (11kV)
$X_{supply\ pos\ seq}$	0,244 Ω (11 kV)
$R_{supply\ zero\ seq}$	8,926 Ω (11kV)
$X_{supply\ zero\ seq}$	2,77 Ω (11 kV)
MV cable length	3 km
R_1	0,4551 Ω
H_1	0,753 mH
R_0	3,4326 Ω
H_0	0,533806 mH
C	799,5 nF
Distribution transformer	
X_{tx}	5,42%
R_1	2,768 Ω (11 kV)
R_2	1,246 m Ω (420V)
$I_{no\ load}$	3,05 A (420 V)
X	84 Ω (420V)
R	243 Ω (420V)
LV cable (mains)	
Length	440 m
Type	Cu 4 core
Size	120 mm²
R_1	0,1844 Ω/km
H_1	0,243 mH/km
R_0	0,7376 Ω/km
H_0	1,0442 mH/km
C	1087 nF / km
Inverter filter	
# Installed	First 20, then 1
$R_{equivalent\ for\ 1}$ (Ω)	0,1
$X_{equivalent\ for\ 1}$ (Ω)	1,038
Household load	
# Consumers	20
Total kW	R = 39,29, W = 39,29, B = 34,92 (ADMD x DF x N_{ph})
Total kVAr	R = 9,85, W = 9,85, B = 8,75 (ADMD x DF x N_{ph})
$R_{equivalent}$ (Ω)	R = 1,267, W = 1,267, B = 1,425 (ADMD x DF x N_{ph})
$X_{equivalent}$ (Ω)	R = 0,318, W = 0,318, B = 0,357 (ADMD x DF x N_{ph})

Table 2: Network parameters.

Harmonic Order	Frequency Hz	Current A R, W	Current A B	Angle (°)	Rlv cable Ω/km 20 deg	Rlv cable Ω/km 75 deg	In A	Neutral P_{loss} W
1	50				0,156	0,189		
3	150	18,952	16,244	-43,41107	0,16	0,194	23	45
9	450	3,729	3,196	-9,997086	0,19	0,230	4,5	2
15	750	2,288	1,961	-94,89791	0,231	0,280	3	1,1
21	1050	2,357	2,020	-79,80126	0,268	0,325	3,1	1,4
27	1350	0,949	0,813	-111,9004	0,299	0,363	1,2	0,23

Table 3: Harmonic currents injected at PCC and neutral losses as a result.

for. All of the frequencies tested for, acts like zero sequence currents, with the sum returning via the neutral. The losses in the neutral due only to the harmonic currents tested, become considerable (see column 9 of Table 3).

Summary

Resonance

Resonance has become a realistic risk to distribution transformers unloaded or lightly loaded as a result of SSEG installations. Especially series resonance under single or two phase switching conditions imposes a risk to the integrity of such transformers due to excessive voltages.

Unbalance LV load/generation

The installation of a single small SSEG has the potential to create voltages beyond legislative limits due to unbalance. It could happen at unexpected positions such as near distribution transformers.

Harmonics

Harmonics generated by SSEG are small compared to existing harmonics on the system. Filters forming part of PV installation could, however, play a role in making the impact of existing harmonics worse.

Conclusion

The utility needs to know of each existing and new SSEG in its area of supply. Even if the SSEG is not grid connected, it could lead to unloaded distribution transformers, especially in rural areas with fewer customers per transformer, which, in return, could lead to over voltages on the transformer phases under certain switching scenarios.

Information pertaining to SSEGs are critical towards verifying their impact on the system. Such detail includes the filter parameters and islanding detection devices. (The latter actually becomes the protection device under certain conditions).

Each new SSEG installation needs verification in terms of its grid impact in line with an extended list of parameters to be checked.

h	R-N @ Tx		NRS048	R-N @ PCC	
N	V	% of 230 V	Limit (%)	V	% of 230 V
3	0,49	0,21	5	3,2	1,39
9	0,31	0,13	1,5	2,5	1,09
15	0,32	0,14	0,5	2,7	1,17
21	0,48	0,21	0,3	3,7	1,61
27	0,24	0,10	0,2	1,8	0,78

Table 4: Harmonic voltage distortions at the 400 V Tx busbar and at the PCC.

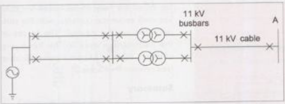


Fig. 13: System supplying distribution transformer.

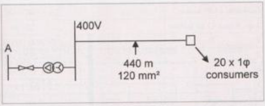


Fig. 14: Elementary LV network checked for harmonic distribution.

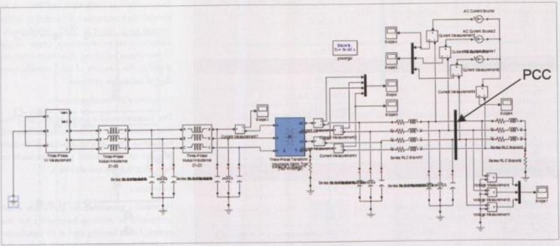


Fig. 15: Equivalent matlab simulink network for testing.

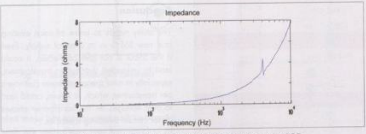


Fig. 16: Equivalent impedance between red phase and neutral at PCC.

Design software should accommodate parameters such as diversity, unbalance, harmonics and resonance with relative ease.

National standards in terms of harmonic generators and their diversity is lacking.

References

[1] B Mather, C Schauder, and various others, Southern California Edison High-Penetration Photovoltaic, Project 1, Technical Report NREL/TP-5500-50875, June 2011.

[2] PH Ferracci, Ferroresonance, Cahier Technique No 190, Technical Collection, Schneider Electric, March 1998.

[3] JA Alberts and JA De Kock, "When Utilities have no Knowledge of Connected Embedded Generators", Wattnow, SAIEE, pp 20 – 35, April 2017.

[4] Q Shi, "Power Quality Impact of Photovoltaic Systems on Residential Distribution Networks", A thesis submitted in partial fulfillment of the requirement for the degree of Masters of Science in Energy Systems, Department of Electrical and Computer Engineering, University of Alberta, 2014.

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Ekurhuleni Metropolitan Municipality's approach to promoting the green economy

by Mark Wilson, City of Ekurhuleni

The City of Ekurhuleni (COE) adopted an Energy and Climate Change Strategy in 2007. From this strategy the COE Energy Department developed and adopted an Energy Plan in 2015. This energy plan aims to reduce the energy demand in COE as well as diversifying our energy mix. The plan sets a target that a minimum of 10% of our energy usage must be from renewables by 2020.

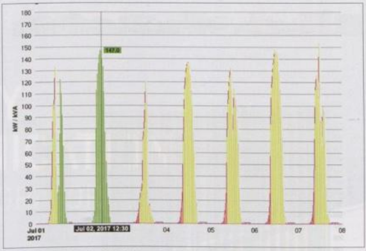

Fig. 1: The weekly profile of the 250 kWp PV installation on the various rooftops of the Boksburg Civic Centre, taken in the first week of July 2017.

The city will achieve this ambitious target in two ways:

- Installing photovoltaic (PV) plants on our own buildings, as well as installing solar water heating and energy efficient street lighting and building lighting. This will be installed and owned by the city on our capital program. We already have almost 1 MW of rooftop PV installed and will install an additional 2 MW in the following three years. Fig. 1 shows the winter output of one of these plants.
- The creation of, and partnering with Ekurhuleni Power Partners (EPP) to generate predominantly renewable energy on a large scale. This is the subject of this paper.

Background

When the COE was formed in December 2000 it incorporated the nine old towns and cities of the East Rand, as well as portions of the Kyalami Metro and the Eastern Gauteng Services Council. It became one of the country's largest metros, as well as one of the largest electricity distributors (see Fig. 2).

As large as COE is, and unlike some other large cities, it has no power stations. Kelvin power station is within the boundaries of COE, but it was incorporated into Johannesburg, given that all the networks it was connected to belonged to the City of Johannesburg.

Until recently, the COE was entirely reliant on Eskom for its power requirements. During the load shedding years the premier of Gauteng proposed a future level of energy independence for Gauteng. Following the 2016 local government elections, our new executive mayor, Councillor Mzwandile Masina put forward the vision for an Ekurhuleni power station.

The Energy Department was given the task of creating our own power station. It was soon apparent that with our limited capital budget of about R700-million per year, it would be next to impossible to build and operate a city-owned power station. Most of our capital is used to fund the city electrification backlog program, which is around 180 000 households.

We have installed about 1 MW of rooftop PV at this stage and will expand to roughly 10 MW by 2020. The city also owns 1 MW of landfill gas electricity generation (see Fig. 3). These are insignificant volumes in our total maximum demand value that exceeds 2000 MW.

Over the last number of years, many companies have approached the COE to supply electricity, offering various realistic and unrealistic technologies.

The COE, as the industrial heart of the country, has to ensure an adequate reliable power supply, taking the city sustainably into the future. The city has a net influx of people from rural areas and has a high unemployment figure, which requires positive and practical job opportunities to effectively deal with this aspect. In addition, the COE needs to reduce emission levels in the city, and the country as a whole.

These requirements led to the idea of creating Ekurhuleni Power Partners (EPP).

The Ekurhuleni Power Partner (EPP) model

In the absence of robust legislation and with many regulations in draft only, the COE, as a sphere of government, designed a model that would fit into these draft regulations as best as possible, whilst still meeting the needs of the city.

Our concept was discussed with the National Department of Energy, as well as the previous Minister of Energy.

The model can be described as outlined below.

Ekurhuleni would call for tenders for power partners, extending over a period of at least 20 years. This being the minimum time deemed necessary to make the investment required to be financially viable.

EPPs would build power stations within the geographical boundaries of the COE. No cross boundary supply will be allowed and power plants would be directly connected to the COE networks. This is to ensure that no complex wheeling arrangements are needed. It also meets the draft regulation idea of own generation for our own needs. Having the plants within our boundaries will also ensure that employment is created within the COE.

All technologies have to be renewable and/or reduce emissions. Natural gas generation of electricity will be allowed.

The main technologies proposed are:

- *Waste to energy:* The COE disposes of almost 2-million tons of mixed waste to four main landfill sites per annum. This will result in the reduction of waste disposal, as well as the generation of a significant volume of electricity.

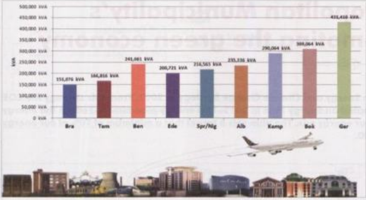

Fig. 2: The demand in every one of the COE Energy Depot areas, these being from left to right, Brakpan, Tembisa, Benoni, Edenvale, Springs/Nigel, Alberton, Kempton, Boksburg and Germiston.

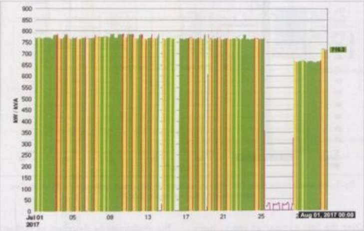

Fig. 3: The monthly profile of the 1 MW landfill gas generation installation on the Simmer and Jack landfill site in Germiston, taken in July 2017, with 480 000 kWh generated in the month.

- *Landfill gas:* The COE has an estimated volume of methane gas from our gas wells and flaring program, to generate between 5 MW and 10 MW. The wells and flares already exist so this could be a quick win.
- *Photovoltaic (PV) electricity generation:* Gauteng has very good levels of solar radiation which are totally under-utilised. Most PV plants are in the Northern Cape which requires long transmission lines and their associated technical losses. By building PV plants in the COE, geographically close to electricity consumers, the slightly lower radiation levels will be more than offset by the reduction in transmission losses. EPPs will be allowed to build a PV plant on their own land within the COE or they can utilise a COE owned farm of almost 500 hectares. This farm is unsuitable for large scale commercial farming, as underground water cannot be pumped out due to dolomitic conditions. It will be ideal for a large PV installation of about 250 MW.
- Natural gas electricity generation.
- Other.

The pricing for the electricity generated (to be paid to the EPPs) shall be a maximum of the Eskom Megaflex Tariff rates as paid by the COE to Eskom. The pricing shall follow the annual NERSA approved Eskom Megaflex increase for the next 20 years. All EPPs shall offer a discount per year with the first three years after power production, commencing with a 0% discount, i.e. the full Eskom Megaflex tariff shall be paid. This three year period will aid start-up and stabilisation. All discounts offered per annum will be grouped per technology and averaged, excluding the highest and lowest discount. The same average discounted rate shall then be paid to each EPP, per technology.

The COE shall apply to NERSA for a generation licence or licenses and the EPP will provide the role of service provider.

EPP implementation

The COE Energy Department obtained "in principle" approval from council to call for tenders exceeding three financial years up to 20 years. A specification was prepared and advertised on 2 September 2016. The tender closed on 4 October 2016 and was awarded on 24 May 2017. The award was made subject to the Section 33 process of the MFMA being concluded, i.e. approval to commit the city budget for a period exceeding three years. It was also subject to a successful power purchase agreement being concluded between the COE and each EPP, as well as the necessary generation licences being obtained from NERSA. The following number of bidders, technologies and average discounts were awarded subject to the conditions named above:

- One company was offered a contract for landfill gas electricity generation to the volume of 5 MW with an average discount of 1% per annum, after the first three years.
- Six companies were offered contracts for waste to energy electricity generation for a total of 139 MW with the minimum of a 5 MW plant and a maximum plant size of 33 MW with an average discount over 20 years of 9,7%.
- Thirty-two companies were offered contracts for PV electricity generation for a total of 288 MW with the minimum of a 5 MW plant and a maximum plant size of 10 MW with the average discount over 20 years of 8,7%.
- Seven companies were offered contracts for natural gas electricity generation for a total of 195 MW with the minimum of a 5 MW plant and a maximum plant size of 50 MW with the average discount over 20 years of 12,4%.
- One company was offered a contract for coal gasification electricity generation for 36 MW with an average discount of 0%.
- One company was offered a contract for KPP Technology (still to be clarified) electricity generation for 10 MW with an average discount of 8,7%.

Conclusion

At the time of writing, the COE had issued a draft PPA for comment. Parallel to this we are following the Section 33 process, as prescribed in the MFMA. Once the Section 33 process is concluded, the COE will enter into individual negotiations for each of the technology groups to conclude the PPAs. Once these two processes have been concluded, the city will approach DoE and NERSA for the issuing of licences.

The city has a long way to go before the first kWh will be generated. We are operating in a new regulatory environment, but we will persist. We have the full support of our executive mayor and council and we believe we shall succeed in defining a new model for power generation in local government.

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Feasibility study to improve electricity distribution performance

by Jean-Luc Farges, EDF, and Peter Neilson, Nelson Mandela Bay Municipality

The objective of this joint feasibility study is to produce a business model on behalf of the Nelson Mandela Bay Municipality (NMBM) to improve the operational performance of the electricity distribution assets combined with an increase in revenues collected. In particular, investing those revenues in the network's operations, as well as the expansion activities would increase the sustainability of the municipality's business model.

During the two missions from 6 March 2017 to 18 March 2017, and from 12 June 2017 to 23 June 2017, we identified a list of key opportunities to improve the collected revenues of NMBM and to optimise the costs to be able to finance the necessary investments in the power system.

The main priority is the need to decrease losses and increase the collection rate. We also propose the related quick win solutions.

The NMBM currently has 10 to 14% electrical losses (14 to 22% on LV) and 7,5% unpaid invoices, so around 17 to 20% (10 to 14% + 86 to 90% x 7,5%) of energy purchased to Eskom is not paid by the customers. This resulted in a loss of R510-million in 2015/16. This trend is not heading in a good direction due in particular to high increases in tariffs every year and the increasing number of customers who can benefit from Assistance to the Poor grants (ATTP).

This situation is further exacerbated by the fact that only a few people within the electricity, energy, budget and treasury directorates work on loss reduction and cash collection. It is therefore necessary to put in place a priority action plan on these two priority issues: loss reduction and improvement of collection.

Table 1 outlines the potential extra revenues, extra collection, or reduction of costs (losses, HR, CAPEX, etc.) in the electricity field alone:

To be added to this total amount the important potential of cash collection for ATTP with R14-million write-offs only for one month in February 2017. This will necessitate a political decision to find the optimal compromise to collect part of this lost cash.

Key actions to decrease losses

The electricity losses level has been around 10 to 14% during the last three years (and 14 to 22% on LV), and was 8% in the past. This represents a loss of R250-million per year.

Key actions to decrease electricity losses:

- Nominate a project director or project manager on losses reduction and receivables management (priority project, transversal approach with different sub-departments, and sections: network, customer management, IT, HR, budget & treasury, etc.).
- Increase fraud/anomalies detection: profitable activity, increase internal staff on this activity, plus external contractor, request fraud detection by field internal/external staff: meter readers and staff in charge of disconnections/reconnections for unpaid invoices. Ask the field staff to detect all types of frauds and not only meter bypasses: include meter tampering, fraudulent connections and reconnections (on unpaid invoices), dismantling of connections for repeat offenders, false ATTP clients.
- Hire private detectives to detect parallel organisations/individuals proposing their services to steal electricity. The intention is to stop the problem at its source.
- Apply internal disciplinary sanctions.
- Connect illegal connections on non proclaimed ervens (around 25 000), but check the business plan. Measure the impacts of electrification (consumption, losses, etc.) and accelerate the process by relying on a consortium of actors.
- Improve the design of metering for domestic clients and oblige when possible the installation of prepayment split meters to decrease fraud. This is particularly relevant for risky clients. Do not put any more meter panels in houses because this makes it easier to commit fraud.
- Action on public lighting that is regularly switched on during the day.
- Quick wins on technical losses (develop a strategy to reduce technical losses).

Key actions to increase the invoices collection rate

The collection rate is 92,5% for all NMBM services, from July 2016 to February 2017, with a decreasing trend due to the high tariff increases and the increase of the ATTP, so more than R1-billion per year of unpaid invoices for all NMBM services (electricity, water, etc.), and more than R250-million per year for electricity alone. Cash collection related to invoices is the responsibility of the budget and treasury directorate of the municipality.

Key actions to increase collection rate include the following:

- Nominate a project director or project manager on losses reduction and receivable management.
- Increase control of ATTP clients' files.
- Start to block the prepayment meters also for indebted ATTP clients (political decision).
- No systematic write-off of ATTP debt after 90 days (political decision).
- In parallel external communication on:
  - How to save electricity, particularly for the ATTP (distribution of leaflets by field commercial staff).
  - The bad impact of unpaid invoices on the general interest.
- Put the pressure on, set KPIs and objectives for the 31 employees in charge of payment collection within the budget and treasury directorate to collect more during the first 21 days after payment due date.
- Potential opportunity to increase the connection fee, in particular for MV clients and big LV clients.
- Accelerate the move from credit to prepayment meters, to improve collection rate, but also to transfer meter reading and disconnection/reconnection staff to fraud detection (they represent more than 100 internal and external employees). Still 7% clients with credit meters.
- Control existing internal and external staff efficiency on cash collection with follow up of KPIs (number of disconnections, connections per team).
- After control of staff efficiency/profitability on cash collection, increase dedicated staff for client disconnection.
- Cut big clients after 45 days.
- Implement close control of EOH activity (external contractor in charge of cash collection on receivables older than 120 days), and prepare plan B if necessary.
- Hire private detectives to identify:
  - Potential fraud/corruption of contractors in charge of cash collection.
  - Parallel organisations/individuals proposing their services to clients to fraudulently reconnect them.
- Apply internal disciplinary sanctions

Improve client services

It is necessary to measure the performance of client services with KPIs. Customer surveys can identify the clients' priorities and satisfaction level per delivered service. EDF proposes a

Extra revenues/collection/costs savings	R million per year
Tariff increases higher than Eskom increase, and higher than inflation: +1% is equivalent to R35-million per year	35
Non collected value for electricity invoices alone is around 7,5% of turnover so around R260-million. Potential improvement 0,5 to 1% per year so around R10- to 30-million per year	20
Losses: losses on MV should be low (2 to 2,5%), losses on LV are around 14 to 22%, so potential to decrease LV losses by 0,5 to 1% per year of 1 800 GWh (estimated flow on LV), so 9 to 18 GWh per year, with 50% decrease of purchase to Eskom, 50% extra invoicing, so average cost-price of R0,94 per kWh, so R10- to 20-million per year	15
Penalties on fraud detection	
Internal staff: extra 400 cases per month (instead of 25 really invoiced today), so extra 400 x R4000 per client x 12 months x 50% really paid by clients: R10-million per year	10
External staff: extra 800 cases per month: R20-million per year	20
HR: 1,5% reduction of payroll through no replacement of leaving staff (retirement and pre-retirement scheme) and higher support from private contractors: R5-million	5
CAPEX optimisation: 5% of total: R10-million	10
Prioritisation, equipment standardisation	
Purchase optimisation	
Total	115

Table 1: Proposed actions to increase profitability.

template of satisfaction survey and how to implement it. This customer survey will give the priorities perceived by the clients themselves in term of services improvement. This survey can be implemented through SMS, phone calls, during client visits in the electricity and energy directorate, customer services, cash desks.

The site visits and data from IT tools helped to get the needed details, and to highlight improvement tracks.

A recommendation is that the front office staff should register on the NMBM data base the customers visits, for all types of visits:

- It would help to get the history of the customer issues.
- Could get a report of how many customers come and the purpose of their visit, their waiting time, etc.
- If you know the visits "load curve", then you can adjust the planning of the front office and back office staff.

There are opportunities to find synergies among all the customer front offices of the municipality through the development of multi-skilled employees.

There is a multiplication of different types of front offices within the municipality:

- The electricity and energy directorate front office for client technical requests; change of meters, new connections, etc.
- The electricity and energy directorate front office for losses control (fraud issues: delivery of fraud invoice for penalties and sometimes also for estimated unmetered supply.
- Cashier desk for invoices payments.
- Water division front office.
- The budget and treasury directorate front office for invoices issues.
- The budget and treasury directorate front office for ATTP requests management.
- Vending stations for prepayment tickets purchases.

This situation does not facilitate client services, and it is a source of confusion and dissatisfaction. Clients are obliged to go to different front desks to solve different issues, and they sometimes have to queue at some front desks while there is a lower activity at other front desks, etc. On the other side there is a lack of synergy between the different front offices so NMBM is obliged to pay more staff to cover all these front offices.

There is an opportunity to train the related staff in order to be able to manage different customer requests. So there is an opportunity to develop the staff, an opportunity to have a more diversified activity and an opportunity to have a better salary. And in the end, the satisfaction of clients will improve.

It appears that a lot of clients call/requests are not correctly managed/solved (such as repair of public lighting outages). So it is necessary to check the process, calculate the KPIs/results, share these KPIs with the field staff with the IT system, and provide improvement solutions based on this objective information.

- *Internal communication:* organise meetings between field artisans and call centre/customer care service staff.
- IT could be updated (new reports, prices updating, automatic data filling, etc.).
- Put in place a proper system to handle customer claims.
- To improve the customer relations, have regular coaching and training about customer excellence.

Improve the quality of supply: reduce the frequency and duration of power outages

Recommendations on how to improve the quality of supply are listed below:

- Put the quality of supply at the heart of the technical policy.
- Nominate a transversal project manager.
- Define KPIs (SAIDI, SAIFI), calculate them and use them to optimise the policies to be implemented.
- Increase operational efficiency:
  - Finalise the new network control system (two systems in parallel).
  - Install automation, remote-controlled switchgears and remote controlled fault indicators on MV network.
  - Review the protection policy (reclosers, fuses, etc.).

Optimise the medium and long term network development

Recommendations on how to achieve this are listed below:

- 20 km of old 66 and 132 kV cables.
- 30 HV/MV substations and MV/MV substations for a peak load of 600 MVA: an oversized HV system, some underloaded HV/MV transformers.
- Design of HV/MV substation to be challenged (double busbars without firewalls).
- A few old substations: to be renovated or suppressed, taking into account MV network upgrading.
- Some leaking HV/MV transformers.
- A complex network: Three voltage levels in the same areas (22, 11 and 6,6 kV):
  - Expensive development.
  - Technical losses.
  - Maintenance costs.
- Numerous and long incidents:
  - Problem of reliability.
  - Consequences of incidents on the MV derivation lines.
  - Lack of network automation and remote control on MV feeders.
- Many underloaded MV/LV substations.
- Many old busbars.
- Safety problems in some MV/LV substations.
- Potential to renew while simplifying and standardising the MV network
- Potential to simplify the network: unify voltage levels, decrease switching substations, and unify MV cross sections.
- Potential to simplify the HV/MV substations scheme.
- Potential to improve sharing of technical information:
  - Better information capitalisation (ex MV feeder loads, MV cable age).

- Implementing a common technical data base.
- Better knowledge about loads localisation (annual peak load treatment).

- Electrification of new areas:
  - Measure the impact of electrification (consumption, losses, etc.).
  - Accelerate the process by relying on a consortium of actors.
- Reviewing some decision making methods:
  - Carry out studies taking into account realistic long term load forecasts.
  - Prioritise investments by using shared criteria.
- EDF will realise a sample study on:
  - 40 MV feeders.
  - 40 MV/LV substations and related LV feeders.
- The methodology will be explained to the planning experts team:
  - LV: Network feeders measurements.
  - LV: GIS use plus on site visit.
  - MV: Power factory use (upgraded loads) and geographical map.

Conclusion

Major recommendations include:

- Improve general management, the use of information system and dashboard/KPIs development for strategic actions.
- *Increase cash collection:* Commercial losses reduction, improve collection rate, more than R100-million per year (i.e. equivalent to more than 40% of NMBM electricity CAPEX, and staff cost).
- *Electrification:* 20 000 to 25 000 illegal connections on non proclaimed ervens. With the measure of the impact of electrification (consumption, losses, etc.) and accelerate the process by relying on a consortium of actors (finance, operation).
- *Improve customer services:* Satisfaction surveys, related action plan, multi-skilled staff at front offices, etc.
- *Improve quality of supply (QoS):* Calculate the SAIDI, manage the QoS, MV network automation.
- *Develop the network development policies:* Refurbishment vs. renewing of HV/MV substations, technical losses reduction, MV network restructuring.

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Mandatory revenue protection initiatives to improve municipal cashflow

by Nzimeni Mgoqi, Centlec and SARPA

This paper will discuss the revenue protection shortfalls within the municipal environment and highlight strategic solutions to fund and support best practices like the establishment of a revenue protection unit and the development of revenue protection processes, in order to counter such shortfalls and improve municipal cash flow, income and service delivery standards.

The problem of electricity theft needs to be discussed and defined.

Theft of electricity:

- Deprives the utility of income.
- Presents a health and safety risk.
- Increases the tariffs for those customers who diligently pay.

One of the myths about electricity theft is that it is a "township problem". The reality is electricity theft is happening everywhere, including in business, industry and commerce.

Meter tampering and bypassing is much more discreet in large installations, sophisticated and difficult to detect, and has the potential to cost the utility much more.

Electricity losses can be in the form of meter tampering, stealing, billing irregularities, and unpaid bills.

Electricity theft can get out of control if strict governance indicators and effective accountability are not applied.

Various initiatives can and have been applied, ranging from technical solutions such as tamper resistant meters to managerial methods as well as inspections and monitoring.

The purpose of this paper is to discuss the current trends and methods of combating this problem, and a future strategy.

Revenue protection shortfalls

One of the most important shortfalls is how we define the electricity loss problem. When you analyse the challenges in municipalities that are struggling financially, you realise how complex the issues are in turning around such an organisation.

Smaller municipalities do not have dedicated revenue protection staff or even an operational budget to counter non-technical loss issues. As dedicated revenue protection sections have recovered up to R18-billion since their introduction, it can be seen as a "no brainer" to go this way. Taking into consideration that customers had to endure a 39% increase in electricity costs since 2012/13, this must be seen as a serious concern for utilities and customers alike. It is estimated that plus minus R9,2-billion in total electricity losses will be incurred in the period 2017/18.

Let's not forget that the total losses are made up of technical losses and non-technical losses. Technical losses are possible to compute and control. However, non-technical losses are due to human manipulation or errors and are therefore external to the power systems.

Taking into consideration that there are clearly defined factors that cause non-technical losses, it is important to address these issues and find solutions in order to minimise the impact of such losses. These issues include:

- Illegal connections
- Meter tampering
- Inaccurate recording of billing consumption
- Data fraud
- Non-read meters
- Inaccurate customer account data
- Indigent tariff
- Lack of punitive action in bylaw enforcement
- Syndicate activities
- No revenue protection section or budget
- Lack of specialisation in combatting revenue losses

Therefore, all we really need in the municipal environment is for all entities and role players to realise the importance of revenue protection processes and the solutions it bring.

Experience has shown that utilities who initiate dedicated revenue protection sections very soon find that these units become self-funding and within a period of as little as two years can claw back significant lost revenue for the utility. Furthermore, one should not forget that audited and reinstated installation are once again the cash register of the utility.

Strategic solutions

Best practices

The best solutions to effectively minimise revenue losses is to focus on revenue protection best practices. This would include the following processes:

- Auditing of meters
- Remedial actions
- Data analysis

> *Extract from "Background Paper for the World Bank Group Energy Sector Strategy"*
>
> "In all successful cases, a large share of non-technical losses was concentrated in users able to pay for cost-reflective tariffs. Thus, non-technical losses can be reduced with little loss of welfare, while their continuation jeopardizes the financial sustainability of the power sector and harms well-behaving selectricity consumers, taxpayers, socially disadvantaged segments, and the country as a whole. Elimination of those losses (with the exception unmetered consumption explicitly and transparently defined in the regulatory framework) should be a matter of high national priority for every country."

- Revenue recovery
- MD meter recertification
- Revenue loss forum

Furthermore, it is very important to appoint a capable revenue protection manager who understands all the utility's policies and processes and who is a go-getter and also a champion. It is also advisable to appoint dedicated staff members to perform both technical and administrative revenue protection tasks. Field staff investigating and reinstating (preferably in a one-stop action) and administrative staff updating master data and adjusting accounts to recoup lost revenue. It has been proven beyond a matter of doubt that temporary staff members do not have the dedication to be able to perform all the tasks required from revenue protection members. The accountability and bottom line responsibility should be on both detection and recovery of revenue, as it is easy to detect but more difficult to recover losses and prosecute the culprits. Focusing on the "big fish" (large power users) first, is a proven concept, as "little guppies" (domestic customers) will only bring in small returns.

Approximately 90% of all tamper cases are found in the domestic environment. This is evident from an analysis done in a large South African munic where, of more than 2100 tamper cases, only 200 were commercial installations, and the remaining 1900 cases were domestic.

Revenue protection department/section

One of the questions that get asked often, is whether utilities should go "big" or "small" when putting structures in place to deal effectively with revenue losses. The stronger and more specialised the revenue protection unit is, the better the results. Just remember a revenue protection unit will always recover its costs and the amount will grow with each year the unit operates.

New specialised positions have become more prominent in the modern day revenue protection department, e.g. revenue recovery, investigations and data analysis. This has been necessitated by the introduction of new technology and smarter metering systems. The data analysis and mining processes have become more important, as smart systems make available different kinds of information that enable one to determine customer consumption patterns. This has however brought new challenges with the introduction of the "big data concept", which requires more resources in order to manage the data effectively.

The most important issues when it comes to establishing a revenue protection unit are as follows:

- It is strongly recommended that the revenue protection unit is housed in totality in the utility service department, water and electricity.
- Proven results exist where utilities have a revenue protection staffing level of one staff member to 5000 meters.
- The unit should be able to have enough manpower to reach their KPIs.
- Knowledge levels of individuals should be integrated to allow them "to think out of the box".
- Certain members responsible for data, revenue recovery and investigations should be specialists in their respective fields and understand all company policies and procedures.
- The revenue protection must be integrated with the normal line functions and be synchronised to simultaneously address issues.
- Highly qualified and energetic members must be deployed to enable the unit to deal fast and effective with problematic issues that causes big losses.
- The interaction between revenue protection, law enforcement agencies and the legal entities should be on a very high level at all times.

Multi-departmental and stakeholder collaboration

In order to reduce losses you also need multi-departmental and stakeholder collaboration between the revenue protection department, techno-commercial units, billing operations, business centres, law enforcement, community leaders and customers.

Focus points

- All actions to reduce losses should be data driven operations.
- Implement close monitoring and proactive restitution.
- KPIs for objective performance measurement is very important and should focus on recovering losses rather than just detecting theft cases.
- Top level management support and involvement is also very important, as revenue protection officials need all the support they can get.

Risks of outsourcing services

Many utilities have been faced with the difficult decision to outsource certain aspects of the revenue business, due to the challenges created by the influx of new technology into the municipal environment. Most of them have opted to go the easier route by completely outsourcing this service. Now in this lies the biggest source of concern, as these outsourced companies are in most cases given a carte blanche to manage the municipalities' income and billing operations. This in itself is a huge risk, except if the total operations is fully scrutinised on an ongoing basis. The question is: how sure are the municipalities that all the monies owed to them do actually reach their coffers?

I think the time has come to take back the controls of our revenue generation processes and rather teach and enable our own employees to perform such tasks. If a municipality does not have the means to do this, we in SARPA would strongly suggest that municipalities should include in their external service providers' contracts that they will train municipal staff members to operate systems and implement processes within a stipulated timeframe. The revenue protection benefit will come in once the municipal employees fully understand the systems, as they will be able to see the loopholes which the service providers can now easily hide away and successfully address it.

The impact of high losses

The real impact of high revenue losses is very difficult to understand in totality, but let us look at what could happen to a municipal entity in South Africa should such losses not be effectively minimised:

- NERSA supply licence could be at risk.
- NERSA approval of new tariffs could be delayed.
- Cash flow income will be reduced.
- There could be more compensation law suits.
- It could escalate into community violence.
- It will definitely cause a lack of faith in political structures who promise service delivery.
- The loss in income will also cause the network to degrade, which will cause more issues.
- There will also be an escalation of operational costs.
- Possible DOL intervention in serving prohibition notices on the CM.

Proposal to obtain funds to reduce losses

The NERSA Licence agreement shortfall is hampering the effort of South African metros and municipalities to effectively reduce revenue losses. The licence agreement states that 6% of the operational income must be used to reduce technical losses, but no provision is made for non-technical losses. Municipalities therefore are not required to provide adequate budget for such losses and therefore not enough funds are made available in metros and big munics and none at all in smaller munics. If there is not enough provision in the budget for revenue protection activities in order to reduce non-technical losses, CFOs will simply ignore such losses until such time when it escalates beyond acceptable levels.

SARPA therefore recommends that a minimum of 1 – 2% of operational electricity income must be used to fund revenue protection programmes until the national standard of 9% electricity losses is achieved. This funds must then be utilised to adequately resource revenue protection staff structures and fund the revenue protection operational budget.

Predicted future

Predicted future of this issue and already noted growth in the problem:

- Civic involvement initiatives e.g. public campaigns to highlight the dangers and effect of tampering.
- Councillor involvement in fighting the scourge.
- Public campaigns to expose tampering customers.
- Public campaigns to discourage theft and warn against dangers and action to be taken.
- Rewards system (e.g. reward for information leading to successful detection of tampering).
- Further improvements in the modus operandi of the revenue protection division.

Processes

Processes currently in place to identify and help combat electricity theft:

- Applying intelligence, "no sales" and low consumption reports.
- Application of prepayment metering to its fullest extent.
- Meter replacement projects.
- Conversion of meters to prepayment split type meters.
- Dedicated staff policing large users (LPU) accounts.
- Detailed feedback from field staff.
- Cooperation from other departments.
- Assistance from meter readers and other support staff.
- Qualified staff performing inspections and reinstatement.
- New modus operandi "one stop shop" approach, eliminating multiple visits with detection and rectification done in single visit.
- Success of "tip-off " line.
- Confessions by public.
- Keeping a check on authorised capacity and notified max demand.
- Full replacement of metering installation.
- Move to AMI for LPU customers.
- Full commissioning test and records.
- Follow-up checks at billing validation.
- Adjustment of accounts i.r.o lost kWh units.
- Full replacement of metering installation.
- Move SPU customers caught tampering to AMI.

What can be done?

Electricity theft can never be totally eradicated. A great deal of effort has been devoted to the technological and managerial methods. Inspection and monitoring is very important as a visible form of policing. A critical step in electricity theft reduction is to become knowledgeable about the theft problem.

- Revenue protection division is continually striving to succeed through participation in regional and national meetings of The Southern Africa Revenue Protection Association (SARPA).
- A future initiative would be the role-out of a smart metering system where this initiative will prove to be economically viable.
- A message of "no pay no electricity" must be applied, instilling a culture of payment among consumers and preventing a culture of non-payment from developing.

Challenges

- There is no tamperproof meter nor kiosk.
- Cultural and behavioural changes are required.
- Meter accommodation challenges.
- Staff are endangered.
- Enemy within, "do it right the first time".
- The 80/20 principle certainly applies.
- Switch-off solution for pockets where tampering is ingrained.
- Continuous staff training to keep abreast with technology and tamper curve.
- Political buy-in and will to assist with awareness campaigns.

Conclusion

In conclusion, it must be mentioned that the entire revenue protection concept has developed in the past 20 years and has now reached a new level of expertise, which has resulted in the need for those involved in such actions to go to the next level of specialisation.

This has come about due to the fast-tracking of the technology development process of metering worldwide. This has triggered the service providers to capture the market and offer all kinds of packages and wonderful solutions.

I want to end off by calling on electricity distribution companies in South Africa to stand together and take back their revenue systems by training their employees to perform such tasks and allocating enough funds to the revenue protection operation budget that the processes can be effectively carried out.

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Advanced revenue programme for large power users

by Martin Kuhlmann, Siemens Digital Grid

This paper focuses on the topic of advanced revenue in relation to large power users in a smart meter AMI programme. It will explore the benefits of advance revenue for bulk and large power users (LPUs) as well as commercial and industrial consumers, converting complex electricity tariffs into LPU advanced revenue, managing the transition from "post-paid billing" to "prepaid/advanced revenue billing" using a smart metering AMI advanced revenue programme, and managing "disconnects/reconnects" for LPUs; and how water meters interface into the same framework.

What are the benefits of "advance revenue" for bulk and LPU CT consumers?

Prepayment is a loose term with reference to electricity metering. It has a stigma attached to STS prepayment meters which predominately meter small power users (SPUs).

For large power users (LPUs) and medium power users (MPUs), there were no STS prepaid meters available on the market. Also, utilities refrained from forcing these consumers to go "prepaid" due to administrative issues such as "disconnects/reconnects", cash flow conversion for especially large power users, and also design on meters that allowed for large prepayment purchases.

LPU consumers are typically large industrial manufacturers and the like which, in some cases, have one or more MV feeds and thus electricity metering requires a three-phase current transformer (CT) meter. Medium power users are typically connected to the LV grid and have a mixture of CT and DC connected meters.

To-date LPU/MPUs are not metered as post payment consumers and have either old analogue metering or high accuracy digital metering, but the meter data is typically read manually and tariff rated into their respective billing engine.

LPU/MPUs typically consume 80% of the utilities total consumption and therefore contribute to 80% of the utilities revenue. Meter population wise LPU/MPUs only cover 20% of the total meter population, whereas SPUs cover 80% of the meter population, but only generate 20% of the revenue.

- LPUs require high accuracy meters (typically 0,2 and 0,2 three-phase CT meters).
- MPUs require medium to high accuracy meters (typically 0,5 to 1,0 three-phase CT or DC meters).

Advanced revenue for large/medium power users (LPU/MPU)

For LPU/MPU consumers, prepayment (or advanced revenue) is a new concept and not readily deployed. These consumers receive post-paid invoices and generally pay 30 to 60 days (with some extremes of 120 to 180 days) after receiving their invoice.

LPU/MPU electricity data is provided on their invoice and is 30 to 60 days post consumption. This makes it very difficult for LPU/MPUs to plan and understand real time consumption data.

The benefits for LPU/MPUs in an advanced revenue environment are:

- They can download and view (typically, depending on the AMI system) online data in terms of real time consumption, billing data etc. This helps the LPU to plan according to real time data (e.g. when to switch on their smelter, etc.).
- Reconciliation happens in a real time mode.
- Tariff rating is done in real time and therefore they can determine their costs, despite the tariff codes being complex.
- Cash flow management – the customer can pay according to their cash flow and consumption plan/strategy, as well as optimise cost saving, etc.
- No manual meter reading and inaccurate data.
- Predictive analysis forewarns the LPU/MPU consumer when they will run out of electricity – a huge benefit for cash flow planning.

The benefits to the utility are immense. Utility cash flow typically moves from 150 debtor days to minus 10 to 15 days – this means that the utility gets cash in advance before electricity consumption – thus allowing for growth planning and strategy.

Real time data is available to the utility and thus allows for planning, growth and value add support to the end consumer, be it LPUs/MPUs or SPUs.

Grid control is enhanced as a real time view of load consumption and trends is available. Depending on the MDM, this type of data can be linked into a SCADA system.

How does a utility introduce complex electricity tariffs into LPU advanced revenue?

Current STS prepayment tariff code structure is based on tiered/linear or static pricing. In the past, complex tariff codes such as time of use (TOU)/max demand/energy charge/network demand charges were difficult to include in prepayment purchases as most of these tariffs require post consumption calculations as well and timing – none of which are available in a STS prepaid environment.

Consumers	
Features	**Benefits**
Siemens Managed Services	Complete piece of mind that the AMI solution is looked after and managed
Low accuracy meters: (typically single phase DC meters)	To help with costing, low accuracy meters will fit the profile of these power users
Positive cash flow – typically minus 15 debtor days due to prepayment	This is a huge value add to the utilities' cash flow
Data is instant – not waiting for 30 to 60 days for bill to arrive with post-consumption meter data	Now the consumer can make strategic decisions, and planning, due to near real time data available
Real time account reconciliation	No more debtors department – Siemens takes care of reconciliations including the bank vendors
Real time complex tariff rating: TOU/max demand, etc.	Caters for any tariff codes and can easily handle multiple codes per account
No manual meter reading and data capture – reduces inaccurate billing	Reduces inaccurate billing
Meter tampering alerts and events – reduce NTL	Reduce non-technical losses

Table 1: Siemens Smart Metering as a Service (SMaaS) for consumers.

A prepaid smart metering AMI system is able to incorporate many different tariff codes and structures as the data we receive on a real time basis allows for intelligent tariff rating.

Also, a smart metering AMI system is able to offer more complex tariff structures than even the post paid billing allows for. All tariffs in an AMI solution are done on a real time basis with real time reconciliation.

How does a utility manage the transition from post-paid billing to prepaid/advanced revenue billing using a smart metering AMI advanced revenue programme?

Typically for LPUs the default method of billing is post-paid. Converting LPUs to prepaid or advanced revenue is a very sensitive task as LPUs spend large amounts on energy usage and are used to the rhythm of paying for their electricity in arrears.

A utility will be required to engage on a one-to-one level with their LU customers to plan for the changeover. This may involve the utility allowing for a transition period for a LPU to pay off their outstanding post-paid bill, and engage immediately on a advanced revenue prepayment structure.

It is really up to the utility to understand their customer, be sensitive to their billing and cash flow, and engage on a personal basis. Typically, only 20% of the customer base are LPUs, so by making a concerted effort on these customers, the utility can plan a relatively easy transition, thus adding benefit to the consumer, and themselves.

How does a utility manage "disconnects/reconnects" for LPUs?

Remotely disconnecting and reconnecting a LPU is extremely difficult and expensive.

The short answer to this question is that a utility should not be doing this activity. There are numerous reasons why, but here are some points to consider:

- Remote disconnects/reconnects work only on direct connect (DC) smart meters (i.e. meters that are directly connected between the utility feed and the consumer's load).
- Current (or voltage) transformers (CT) smart meters cannot be remotely disconnected/reconnected as the meter in not in direct line between the utility/grid feed and load.
- There are very few LPUs that have CT meters, so one-to-one LPU customer management in this case is imperative. These types of customers have complex industrial machinery and plants that most often, require staged shutdown and restart. Just by switching off can cause immense damage and cost to the utility.
- By using predictive analysis, the smart metering AMI system can allow for advanced communication to the LPU forewarning them of imminent shutdown due to non-payment. A suggestion would be that at the last minute, a phone call to explain that the feed will be shutdown and that the LPU needs to either make payment, or stage a shutdown of their machinery.

Utilities	
Features	**Benefits**
Siemens Managed Services	Complete piece of mind that the AMI solution is looked after and managed
Multiple meters per account	Can offer the likes of LPUs all their metering points as one account
High accuracy meters: (typically three-phase CT meters)	Making sure that meter reads are very accurate due to large consumption values
Positive cash flow – typically advance 15 debtor days due to prepayment	This is a huge value add to the utilities' cash flow
Data is instant – not waiting for 30 to 60 days for bill to arrive with post-consumption meter data	Now the utility can make strategic decisions, and planning, due to near real time data
Real time account reconciliation	No more debtors department – Siemens takes care of reconciliations including the bank vendors.
Real time complex tariff rating: TOU/max demand, etc.	Caters for any tariff codes and can easily handle multiple codes per account
No manual meter reading and data capture	Reduces inaccurate billing to zero
Meter tampering alerts and events	Reduce non-technical loss to zero
CT/PT ratio detection	This feature helps a utility reduce massive inaccurate CT ratio losses ±30% extra
Phase data measurement and detection	Helps detect NTL on phase – revenue protection

Table 2: Siemens Smart Metering as a Service (SMaaS) for utilities.

How do water and gas meters interface into the same framework as above?

Typically in a utility, water and gas departments are separate and no interoperations between them are found. Thus each department duplicates each other forcing high cost budgets. Theses duplicate areas are typically:

- Field service engineers
- Support personnel
- Separate systems
- Separate billing
- Staff, etc.

One of the most pressing issues to a utility or municipality is revenue collection and profitability. Electricity revenue is very important to both a utility and municipality as budget allocation is very high. In a water department, there are high costs with, normally, large revenue losses and no profitability.

Security of revenue (SoR) is very sought after in terms of smart meter AMI solution justification. This is despite the accuracy and relevance of data it offers.

Combining smart electricity/water and gas meters to a AMI solution offers huge benefits to a utility.

Combining electricity/water and gas meters onto one system allows for:

- Instant view of all the meters with one end user portal login.
- Instant account and meter data visibility for the consumer – more consumer centric control.
- Ease of information and electricity payment using smart phone apps, etc.
- Prepayment:
  - Link existing STS vending PoS to backend system.
  - Keeps existing payment habits the same.
- Improved cash flow – i.e. reduce debtor days.
- When "central wallet" is depleted (i.e. the balance is zero) the prepayment AMI solution allows one (or more) meters to be controlled such as:
  - Disconnect the smart electricity meter remotely, while leaving the water meter to continue to meter, or remotely throttle the water flow (applicable by law in SA).
  - End user top up transaction is then controlled by the "central wallet" which first allocates the "negative balance" caused by water or gas consumption to be paid first, leaving the difference to be allocated to the electricity meter.
  - If the "central wallet" has positive balance, the electricity meter is reconnected.

Water and gas meters interface into the same AMI framework as electricity meters as the data is read separately by the MDM, and apportioned to the "prepayment application"

Continued on page 103...

Implications of the Occupational Health and Safety Act on electrical installations

by JP Malatse, Department of Labour

The Occupational Health and Safety Act, Act 85 of 1993, is there, inter alia, for the protection of persons where machinery is involved. Some trades may be regulated as stated in the constitution where persons' health or safety may be endangered. The electrical trade is one of the trades that are regulated by an act and regulations.

The Department of Labour administers the Electrical Installation Regulations and Electrical Machinery Regulations. These regulations apply to all sectors e.g. domestic, commercial, industrial and agriculture. It also applies to temporary electrical installations on constructions sites, remote places, etc.

The department has appointed inspectors to ensure that these regulations and incorporated standards are enforced. The department has also approved inspection authorities to assist the department with the enforcing of these regulations.

Persons involved with electricity and those who are using electricity, their lives may be endangered when working on or close to electricity, when electrical machinery are not correctly installed, and when electrical machinery do not comply with standards.

Registration

This is the reason why the Department of Labour registers persons who are involved with electrical installation work. Electrical contractors who are involved with electrical installation work must also register with the department. There are also other machinery where persons and entities have to register, such as for pressure equipment, and gas installations, lifts, escalators, passenger conveyors.

The department registers electrical testers for single phase, installation electricians and master installation electricians.

Safety of electrical installations

The safety of electrical installations are confirmed by a certificate of compliance issued by a registered person.

The department has appointed approved inspection authorities to validate certificates of compliance and to investigate incidents.

The electrical supplier may also inspect and test electrical installations at any reasonable time on condition that they not charge the user or lessor for such inspections and tests unless the inspection or test is carried out at the request of the user or lessor.

It must be noted that there are no other persons to invalidate Certificates of Compliance (CoC) in terms of the regulations.

STAATSKOERANT, 11 DESEMBER 2015 No. 39504 25

DEPARTMENT OF LABOUR

NO. 1225 11 DECEMBER 2015

OCCUPATIONAL HEALTH AND SAFETY ACT (ACT NO. 85 OF 1993), AS AMENDED

INCORPORATION OF SAFETY STANDARDS INTO ELECTRICAL INSTALLATION REGULATIONS, 2009

I, T. Szana, appointed as the chief inspector in terms of section 27(1) of the said Act, and by virtue of the powers delegated to me by the Minister of Labour in terms of section 42(1) of the Act, after consultation with the Advisory Council for Occupational Health and Safety, hereby, under section 44 of the Occupational Health and Safety Act (Act No. 85 of 1993), as amended, incorporate into the Electrical Installation Regulations, 2009, the safety standard specified in the Schedule and shall come into effect on 1 April 2016.

T. Szana
Chief Inspector

SCHEDULE

Standard of South Africa:

SANS 10142-2: The wiring of premises Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 MVA installed capacity

Fig. 1: Safety standard amendment to the Occupational Health and Safety Act.

ISBN 978-0-626-27476-4

SANS 10142-2:2014
Edition 1.1

SOUTH AFRICAN NATIONAL STANDARD

The wiring of premises

Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 MVA installed capacity

WARNING
This standard references other documents normatively

Published by SABS Standards Division
[illegible]
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Fig. 2: The South African National Standard relating to the wiring of premises.

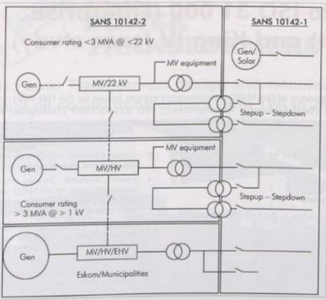

Fig. 3: Single-line diagram showing where the two standards are applicable.

except for the purpose of testing and the completion of the CoC by a registered person. This requirement does not apply where the electricity was disconnected for nonpayment.

Municipal infrastructure

Most technical requirements were removed from the old EMR and placed in the standard, SANS 10280-1 that is incorporated into the regulations.

Some technical requirements are still in the regulations such as:

- Distance of power lines from explosive magazines
- Power lines crossing over water
- Encroaching minimum safety clearance
- Control of vegetation
- Protection of overhead conductors and live parts

SANS 10280-1 deals with the safety of overhead power lines and should be one of the requirements when the municipality give out a tender.

This standard applies to new infrastructures, unless otherwise indicated in the standard.

When this standard was developed for the design of overhead power lines, cost was also considered, but not to the detrimental of safety and health of persons.

Approved inspection authorities

Approved inspection authorities are public entities who deliver services to the industry and any person who is using electrical installations.

The costs for their services are not regulated, so as the costs that are charged by electrical contractors.

Design and construction

The design on an electrical installation above 1 kV shall be approved by a person deemed competent in terms of paragraph (b), (c) or (d) of the definition of a competent person in regulation 1 of the General Machinery Regulations or a person registered in a professional category in terms of the Engineering Profession Act.

The electrical installations above 1 kV shall comply with SANS 10142-2. It does not include any machinery of the supplier related to the supply of electricity on the premises.

The single line diagram in Fig. 3 shows where the two standards are applicable.

Commencement of work

No person shall commence installation work which requires a new supply or an increase in electricity supply capacity unless the supplier has been notified thereof in the form of Annexure 4. The supplier may waive this requirement or replace it with another form.

Supplier may not connect supply to an electrical installation without a CoC

Conclusion

The municipality must make sure that their infrastructures are safe and well maintained. The act and regulations are available on our website www.labour.gov.za

The impact of not being able to supply customers with electricity will be huge on the industry.

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...continued from page 101

appropriately, thus allowing for separate data visibility, but allowing for a "central wallet" to combine the tariff rated data of the separate meters and shown to the end user as one holistic view – thus making it easy to provide for SoR.

Conclusion

With the growing acceptance of smart metering to provide real time big data, and with utilities in developing countries requiring a solution that caters for security of revenue, the effectiveness of a well managed smart meter AMI deployment needs to include the manageability of advanced payment (prepaid) that enhances cash flow and profitability, reduces NTL, and adds huge value to both the end user and the utility.

Despite the huge capital expenditure (CAPEX) a smart metering AMI solution has far reaching benefits that justifies the project.

CAPEX can also be avoided in setting up and operating a smart meter AMI advanced revenue payment deployment by opting for an operation expenditure (OPEX) solution – typically this is referred to as "AMI in the cloud" or smart metering as a service solution.

An "AMI in the cloud" solution offers multiple benefits to a utility, the biggest benefit being cash flow and the reduction for any CAPEX spend. While the argument by many utilities may be a concern for where the data is kept and its security these questions and concerns can be answered, but the reassuring point is that a utility can engage with a smart meter AMI advanced revenue payment deployment at a low base, i.e. they pay on a "meter-per-month" basis as and when a smart meter is installed.

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SHEQ alignment to ISO 31 000 (Enterprise Risk Management) and King IV (case study)

by JL Tefu, City Power

This presentation gives an outline of performance of the SHEQ management system based on the ISO 9001:2008 (Quality Management), ISO 14001:2004 (Environmental Management), ISO 31000:2009 (Enterprise Risk Management) and OHSAS 18001:2007 (Occupational Health and Safety) standard requirements.

The SHEQ department is the custodian of an integrated SHEQ management system (IMS) and is poised to ensure that City Power drives the component of compliance and assurance within the safety, health, environment and quality sphere, in the form of integrated sustainability reporting in line with the requirements of various pieces of legislation; policies and procedures; by-laws; codes of ethics (King IV) and any relevant standard applicable to the business processes.

Top management reviews the business processes/operations of the IMS to align its implementation to the objectives of the overall business strategy for continual improvement. The elimination, prevention, mitigation and management of potential safety, health, environmental and quality impacts relative to the transmission and distribution of electricity and the maintenance of the network forms an integral part of the business plan alignment.

The terms of reference are outlined below:

- King IV
- Companies Act, 2008
- OHS Act, Constitution etc.
- United Nations Principles
- ISO Standards
- Sustainability Report
- Global Reporting Index
- JSE Listing Requirements
- City Power Risk Assurance and Compliance Committee (Terms of Reference).

City Power – The core business

City Power Johannesburg (SOC) Ltd is the energy distribution service provider to the service authority, Johannesburg Council. The core competency of the business is to purchase, distribute and sell electricity within its geographical footprint of business. The City of Johannesburg is the sole shareowner. The council, by means of a service delivery agreement, regulates the service in respect of financial issues (such as tariffs and capital expenditure), human resource issues (such as skills development), delivery targets (maintenance of assets and addressing assets), and standards of customer care. City Power contributes over R14-billion revenue to the economy of the City of Joburg, of which 64% is from business and 36% from domestic and prepaid.

Mandate

The mandate by the board/Exco expects the SHEQ group to:

- Align to the Memorandum of Association and the Articles of Association (the constitution of the company which provides the legal framework within which it operates as stipulated in the Company's Act 2008 and King IV Principles (charter).
- Comply effectively and efficiently with all legislative and other relevant protocols.
- Identify, evaluate, develop, monitor and continuously review SHEQ related strategies and advise management about the impact of such to the business.
- Develop integrated reports (Global Reporting Index) regarding the business performance on SHEQ related matters (sustainability report).
- Sustain the ISO certification – SABS/transition to 2015 version and alignment to ISO 31 000 (ERM).
- Continuous improvement.

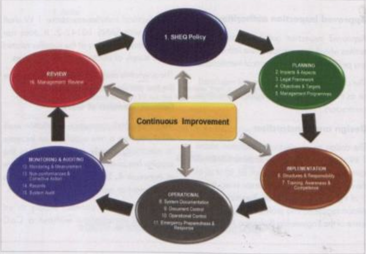

Fig. 1: The SHEQ hybrid model.

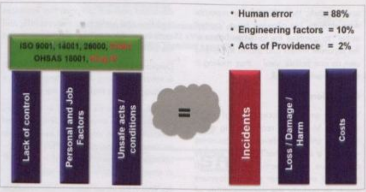

Fig. 2: The loss causation model.

ISO 31000	SHEQ	ISO standards	King IV
Manages the company's risks. Incorporates risk management into the company's governance, planning, management, reporting, etc.	Ensures that the organisation adheres to all the safety, health, environmental and quality standards set out internationally.	Standardises practices to what is acceptable internationally.	Good ethical culture and performance.
Minimises harmful effects caused by risks.	Ensures that the organisation is run properly and fluidly.	Ingrained quality enables competitiveness with international companies.	Controlled effectively and legitimately. Aligns risks to meet strategic operations.
Uses risks as advantages to achieve objectives.	Ensures that the organisation is constantly maintained and improving.	Gives clients a greater guarantee that products meet a certain standard.	

Table 1: Compatibility of the systems.

Fig. 3: The risk management process.

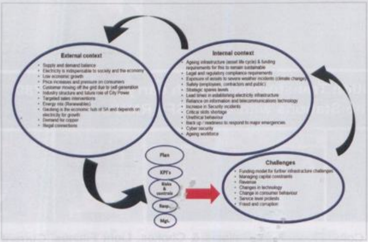

Fig. 4: City Power risk management context.

Governance

The guidelines regarding governance are:

- The roles, responsibilities and authorities of personnel who manage, perform and verify activities which affect the occupational health and safety risks of the activities, facilities and processes of the organisation, shall be defined, documented and communicated to facilitate OH&S management.
- Visible and felt leadership.
- Approval/signing of policy.
- Lead by example.
- Participation in audits.
- Open-door policy.
- Provision of the required resources.
- Consistency in discipline.
- Sustainability.
- Continuous improvement.

Responsibility/accountability

Details on responsibility/accountability are outlined as follows:

- The SHEQ department is the custodian of the Integrated SHEQ Management System.
- The Risk, Assurance and Compliance Committee oversees specific development, approval and review of the framework.
- The framework is subject to the mandate and commitment of Exco and the board.
- All staff must carry risk management activity consistent with the approved SHEQ framework. Staff shall generally identify, communicate and respond to expected or emerging risks within their areas of responsibility.
- Managers and supervisors are responsible for implementation of the framework within their individual business units.

SHEQ hybrid model

The SHEQ hybrid model is outlined in Fig. 1.

Loss causation model

The philosophy for SHEQ management is based on the Safety, Health and Environmental risk policy of City Power which states: "We believe that the safety, preservation and security of City Power assets, i.e. employees, customers, suppliers, plant equipment and the quality of the environment in which we operate, should be protected and conserved. We undertake to safeguard them as far as reasonably practicable, from injury, degradation or damage arising from any of the company's operations (see Fig. 2)."

Risk management process (strategic alignment)

Enterprise risk management is a process effected by the City Power Exco, board of directors and management, applied in strategy setting and across the business aimed at identifying potential events that may affect the company and manage risk to be within the approved risk appetite and to provide reasonable assurance regarding the achievement of City Power's objectives (see Fig. 3).

Principle 11 – King IV

The governing body should govern risks in a

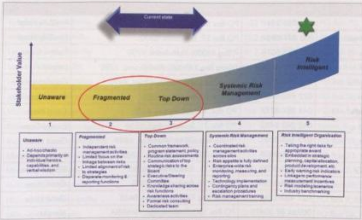

Fig. 5: Factors of risk maturity.

Period	Description
2002 - 2004	R22-million hours accident free and NOSA 3 Star (Northern Region) NOSA 4 Star Platinum (Northern Region)
2004 - 2005	NOSA Best Effective SHE System Award within the H sector (water, gas and energy)
2008 - 2009	SABS ISO 14001:2004 and OHSAS 18001:2007 certification (The first MoE nationally to achieve ISO certification in ISO 14001: 2004 and 18001:2007 standards) Sustained the first SABS ISO 14001:2004 and 18001:2007 surveillance audits
2010 - 2011	SABS certification ISO 9001:2008 (2009/2010) Sustained the first ISO 9001:2008 surveillance audit by SABS Environmental Green Award
2012 - 2013	SABS President's Award Maintained the ISO accreditation and certification for three consecutive years
2014 - 2015	ISO 26000:2010 (social and ethics) compliant. Shift worker health assessments (risk based) – establish baseline health data; identify health deviations in order to treat and prevent progression of such deviations; promote worker performance and prevent the possibility of future litigation; duty to inform – assist employees to understand the health hazards associated with shift work DoL Electrical Forum membership Successfully passed the ISO 31000:2009 (Enterprise Risk Management) Gap Analysis Audit (Stage1 & 2) DIFR < 1 since 2002/2003
2016	Maintained the ISO accreditation and certification for six consecutive years

Table 2: The achievements of the model.

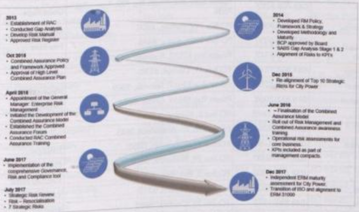

Fig. 6: The risk management journey.

way that supports the organisation in setting and achieving its strategic objectives. Unlike the previous King Codes, the King IV Code now applies to all private sector companies and public sector organisations, and now also includes all metros and municipalities (i.e. categories A,B and C as per the Municipal Structures Act, and includes all MOEs like City Power JHB).

City Power risk management context

The City Power risk management context is outlined in Fig. 4.

Risk maturity

Factors relating to risk maturity are outlined in Fig. 5.

Systems compatibility

Details on the compatibility of the systems are outlined in Table 1.

Risk management journey map

The risk management journey is mapped in Fig. 6.

Benefits

The benefits are:

- Integrated process to allow for ISO management systems to operate in one methodical manner.
  - The organisation can be run optimally.
- Opportunity for quality and continuous improvement in the management system.
  - Compliant with laws and regulations.
- Introduction of risk and opportunity management.
  - Customer and employee satisfaction.
- Creates a stronger framework and governance to achieve the desired outcomes.
  - Documented processes.
  - Documents can be easily accessed and effectively managed.
- Standardised processes with built-in risk measurements.
  - Ensures awareness of what is to come and will be able to deal with all situations.
- Continuous improvement.
  - Organisation and their processes constantly improve and manage risk.
- Customer and employee satisfaction.
- Creates a well-functioning organisation.

Achievements

The achievements in this regard are detailed in Table 2.

Conclusion

The advantages of implementing these entities lead to well-functioning businesses that will satisfy both employees and clients and ensure that the organisation complies with all statutory and legal requirements. This results in business excellence and a thriving organisation.

Contact Joe Ledile Tefu, City Power, Tel 011 490-7131, jtefu@citypower.co.za

AMEU Utility and Engineer Members

Organisation	Name	Phone	Postal address	Branch
Abaqulusi Municipality	Ken Tupper	034 982-2947	PO Box 57, Vryheid, 3100	KwaZulu Natal
Alfred Duma Local Municipality	Oscar Hlatshwayo	036 637-6804	PO Box 29, Ladysmith, 3370	KwaZulu Natal
Amahlathi Local Municipality	Hans Moerdyk	043 683-5016	P/Bag X4002, Stutterheim, 4930	Eastern Cape
Ba-Phalaborwa Local Municipality	Neels Lourens	015 780-6414	Private Bag X 01020, Phalaborwa, 1390	Limpopo
Beaufort Wes Local Municipality	Roelof van Staden	023 415-2276	Private Bag 582, Beaufort West, 6970	Good Hope
Bergrivier Municipality	Neels Rossouw	022 913-6000	PO Box 60, Piketberg, 7320	Good Hope
Bitou Local Municipality	Peter Harpestad	044 501-3277	PO Box, Plettenberg Bay, 6600	Good Hope
Blue Crane Route Local Municipality	Vuyani Appolis	042 243-6442	PO Box 21, Somerset East, 5850	Eastern Cape
Breede Valley Municipality	Henk Benecke	023 348-800	Private Bag x3046, Worcester, 6849	Good Hope
Buffalo City Metropolitan Municipality	Robert Ferrier	043 705-9605	PO Box 2001, Beacon Bay, 5205	Eastern Cape
Camdeboo Municipality	Albertus van Zyl	049 807-5700	PO Box 71, Graaf Reinet, 6280	Eastern Cape
Cape Agulhas Municipality	Steve Cooper	028 425-5500	PO Box 51, Bredasdorp, 7280	Good Hope
Cederberg Municipaliteit	Jacob van Zyl	027 432-1112	Private Bag X2, Clanwilliam, 8135	Good Hope
CENORED	R Bauer	00264 67 30470	PO Box 560, Otjiwarongo, NAMIBIA	Namibia
CENTLEC	Leon Kritzinger	051 409-2213	Private Bag X14, Brandhof, 9324	Free State
City of Cape Town	Leslie Rencontre	021 444-8499	3rd Floor, Civic Centre, Cape Town, 8000	Good Hope
City of Tshwane Metro Municipality	Frans Manganye	012 358-4213	PO Box 423, Pretoria, 0001	Highveld
City of Windhoek	Lukas Kauvi	00264 612 903351	PO Box 59, Windhoek	Namibia
City Power	Tiaan Ehlers	011 490-7320	40 Heronmere Rd, Booysens, 2016	Highveld
Copperbelt Energy Corporation	Neil Croucher	+26 02 122 4400	PO Box 20819, Kitwe, Zambia	International
Dawid Kruiper Municipality	Hennie Auret	054 338-7145	Private Bag X6003, Upington, 8800	Free State
Department of Local Government Western Cape	Leon Eksteen	021 483-3154	7th Floor Waldorf, Building, 80 St. George's Mall, Cape Town, 8001	Good Hope
Ditsobotla Municipality	William Moserwa	018 633-3811	PO Box 7, Lichtenburg, 2740	Highveld
Drakenstein Municipality	Willem Albertyn	021 807-4663	PO Box 1, Paarl, 7622	Good Hope
Ekurhuleni Metropolitan Municipality	Mark Wilson	011 899-4027	PO Box 215, Boksburg, 1460	Highveld
Elundini Municipality	Luyanda Rozani	045 932-8194	PO Box 1, Maclear, 5480	Eastern Cape
Emadlangeni Municipality	Ryno Els	034 331-4540	PO Box 11, Utrecht, 2980	KwaZulu Natal
Emfuleni Local Municipality	Tshabi Tshabalala	016 422-1203	PO Box 3, Vanderbijlpark, 1930	Highveld
Emthanjeni Municipality	Samuel Mgijima	053 632-9100	PO Box 42, De Aar, 7000	Cape Midlands
Endumeni Local Municipality	Mark Donaldson	034 212-2121	Private Bag X2024, Dundee, 3000	KwaZulu Natal
Enoch Mgijima Municipality	Peter Bezuidenhout	045 807-6000	PO Box 7111, Queenstown, 5319	Eastern Cape
Ephraim Mogale Local Municipality	Johan Durie	013 261-8454	PO Box 2925, Marble Hall, 0450	Limpopo
Erongo Regional Electricy Distributor Company	Gerhard Coeln	00264 642 14600	Private Bag X5017, Walvis Bay, 9000	Namibia
ERWAT	Jack Rogers	011 929-7027	PO Box 13106, Norkem Park, 1631	Highveld
Eskom Holdings SOC	Thys Möller	043 703-2293	Postnet Suite 363, Private Bag X22, Tygervalley, 7536	Good Hope
eThekwini Municipality	Maxwell Mthembu	031 311-9005	PO Box 147, Durban, 4000	KwaZulu Natal
Gamagara Municipality	Jerome Bob	053 723-6000	PO Box 1001, Kathu, 8446	Free State
Ga-Segonyana Municipality	Lucas Monyela	053 712-9372	Private Bag X1522, Kuruman, 8460	Free State
George Municipality	Kevin Grüneweld	044 803-9249	PO Box 19, George, 6530	Good Hope
Govan Mbeki Municipality	Sibusiso Rasmeni	017 620-6283	Private Bag X1017, Secunda, 2302	Mpumalanga
Greater Giyani Municipality	Dayson Ntlemo	015 812-2068	Private Bag X9559, Giyani, 0826	Limpopo
Greater Kokstad Municipality	Denis Barker	039 727-2625	PO Box 8, Kokstad, 4700	KwaZulu Natal
Greater Letaba Municipality	Bheki Tshawe	015 309-9246	PO Box 36, Modjadjiskloof, 0835	Limpopo
Greater Tzaneen Municipality	Moswatse Lelope	015 307-8165	PO Box 4239, Tzaneen, 0850	Limpopo
Hessequa Local Municipality	Justin Lesch	028 718-8000	PO Box 29, Riversdale, 6670	Good Hope
Hibiscus Coast Municipality	Nandi Sihlali	039 688-2000	PO Box 5, Port Shepstone, 4240	KwaZulu Natal
Inkosi Langalibalele Municipality	Cyril Moodley	036 342-7800	PO Box 15, Estcourt, 3310	KwaZulu Natal
Inxuba Yethemba Local Municipality	Sipunzi Mteza	048 881-1515	PO Box 24, Cradock, 5880	Eastern Cape
Kai Garib Local Municipality	MW Clarke	054 431-6300	PO Box 174, Kakamas, 8870	Free State
Kannaland Local Municipality	Ismail Buis	028 551-1023	PO Box 30, Ladismith (KAAP), 6655	Good Hope
Knysna Municipality	Michael Rhode	044 302-1603	PO Box 21, Knysna, 6570	Good Hope
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AMEU Utility and Engineer Members

Organisation	Name	Phone	Postal address	Branch
Kwadukuza Municipality	Nick Hall	032 946-8005	PO Box 72, Stanger, 4450	KwaZulu Natal
Langeberg Municipality	Chris Vorster	023 626-8266	Private Bag X 2, Ashton, 6715	Good Hope
Lekwa Local Municipality	Marks Mabunda	017 712-9600	PO Box 66, Standerton, 2430	Mpumalanga
Lephalale Municipality	Eddie Jacobs	014 763-2193	Private Bag X136, Lephalale, 0555	Limpopo
Lesedi Local Municipality	Isaac Rampedi	016 492-0049	PO Box 210, Heidelberg, 1441	Highveld
Madibeng Local Municipality	Jacobus Mynhardt	012 318-9360	PO Box 3575, Brits, 0250,	Highveld
Makana Municipality	Mzomhle Radu	046 603-6062	PO Box 176, Grahamstown, 6139	Eastern Cape
Maletswai Local Municipality	SJ Mosenene	051 633-2406	Private Bag X1011, Aliwal North, 9750	Free State
Matzikama Local Municipality	Deon Engelbrecht	027 201-3402	PO Box 98, Vredendal, 8160	Good Hope
Mbombela Local Municipality	Jaco Landsberg	013 712-8805	PO Box 33, Nelspruit, 1300	Mpumalanga
Merafong City Council	Ezra Shange	018 788-9656	PO Box 3, Carletonville, 2500	Highveld
Metsimaholo Municipality	Hennie van Wyk	016 973-8310	PO Box 60, Sasolburg, 1947	Highveld
Midvaal Local Municipality	Johan Dreyer	016 360-5810	PO Box 9, Meyerton, 1960	Highveld
Mkhondo Municipality	Alfred Mambane	017 826- 2211	PO Box 23, Piet Retief, 2380	Mpumalanga
Modimolle Local Municipality	Antoon Edwards	014 717-1254	Private Bag X1008, Modimolle, 0510	Limpopo
Mogalakwena Local Municipality	Johanes Fourie	015 491-9601	PO Box 34, Mokopane, 0600	Limpopo
Mogale City Local Municipality	Attie Pretorius	011 951-2440	PO Box 94, Krugersdorp, 1740	Highveld
Moqhaka Municipality	Louis Greef	056 216-9284	PO Box 302, Kroonstad, 9500	Free State
Mossel Bay Local Municipality	Charles Geldenhuys	044 606-5083	PO Box 306, Mosselbay, 6500	Good Hope
Msunduzi Municipality	Eveon Nomnganga	033 392-5000	PO Box 399, Pietermaritzburg, 3200	KwaZulu Natal
Municipal Council of Mbabane	Artwell Dludlu	+268 760 240 97	PO Box 13, Luve, Swaziland, M209	International
Musina Local Municipality	Petrus Jansen	015 534-6100	Private Bag X611, Musina, 0900	Limpopo
Namibia Energy Institute	Helvi Ileka	+264 61 207 2011	Private Bag 13388, Windhoek	Namibia
Nampower	Braam Vermeulen	061 205-2961	PO Box 2864, Windhoek	Namibia
Nelson Mandela Metropolitan Municipality	Peter Neilson	041 392-4282	PO Box 369, Port Elizabeth, 6000	Eastern Cape
Newcastle Municipality	Lindile Zincume	034 312-1296	Private Bag X6621, No 4 Vlam Crescent, Newcastle, 2940	KwaZulu Natal
Nored Electricity	Frans Petnen	065 282-2105	PO Box 639, Ondangwa, Namibia	Namibia
NW405 Ventersdorp/Tlokwe Local Municipality	Johan van den Berg	018 299- 5352	PO Box 113, Potchefstroom, 2530	
Oshakati Premier Electric	Leon Hanekom	+26 46 522 0229	PO Box 1594, Oshakati, Namibia	
Oudtshoorn Municipality	Corrie Greeff	044 203-3159	PO Box 255, Oudtshoorn, 6620	Good Hope
Overstrand Municipality	Koos du Plessis	028 313-8000	PO Box 20, Hermanus, 7200	Good Hope
Phokwane Municipality	Tienie Blaauw	053 474-9700	Private Bag x3, Hartswater, 8570	Free State
Pixley Ka Seme Local Municipality	Eugene van Dyk	017 734-6100	Private Bag X9011, Volksrust, 2470	Mpumalanga
Polokwane Municipality	Clarence Pienaar	015 290-2113	PO Box 111, Polokwane, 0700	Limpopo
Rustenburg Municipality	Bert Stols	014 590-3170	PO Box 550, Rustenburg, 0300	Highveld
Saldanha Bay Local Municipality	Johan du Plessis	022 701-7066	Private Bag x12, Vredenburg, 7380	Good Hope
SALGA	Lucky Ngidi	012 401-4716	PO Box 40343, Arcadia, 0007	Highveld
Setsoto Local Municipality	Arthur John Addinall	051 933-9302	PO Box 116, Ficksburg, 9730	Free State
Sol Plaatje Municipality	R Coertze	053 830-6402	CEE – Section, Private Bag x 5030, Kimberley, 8301	Cape Midlands
Stellenbosch Municipality	Johannes Coetzee	021 808-8770	Ecclesia Building, Plein Street, Stellenbosch, 7600	Good Hope
Steve Tshwete Municipality	Setsoto Kholoki	013 249 7226	PO Box 14, Middelburg, 1050	Mpumalanga
Swartland Municipality	Roelof du Toit	022 487-9400	Private Bag X52, Malmesbury, 7300	Good Hope
Swellendam Local Municipality	Salman Herbst	028 514-8500	PO Box 20, Swellendam, 6740	Good Hope
Thabazimbi Local Municipality	Gopolang Booysen	014 777-1525	PO Box 90, Thabazimbi, 0362	Highveld
Theewaterskloof Municipality	Francois du Toit	028 214- 3365	PO Box 24, Caledon, 7230	Good Hope
Tswaing Municipality	Gabatlolae Moleboge	053 948- 0900	PO Box 207, Delareyville, 2770	Cape Midlands
uMlalazi Municipality	Jaap le Grange	035 473-3410	P O Box 37, Eshowe, 3815	KwaZulu Natal
Umvoti Local Municipality	Gerhard Balzer	033 413-9119	PO Box 71, Greytown, 3250	KwaZulu Natal
Victor Khanye Municipality	Floyd Mashele	013 665-5754	PO Box 6, Delmas, 2210	Mpumalanga
Witzenberg Municipality	Pierre van den Heever	023 316-8540	PO Box 44, Ceres, 6835	Good Hope

AMEU Affiliate Members

Organisation	Name	Phone	Postal address	Branch
ABB South Africa	Annemarie Johnson	011 579-8258	Private Bag X10004, Edenvale, 1610	Highveld
Aberdare Cables	Sam Kgosana	011 456-4200	PO Box 5093, Johannesburg, 2000	Highveld
Accenture South Africa	Melusi Maposa	011 208-3000	PO Box 1587, Kelvin, 2054	Highveld
ACTOM Electrical Products	Elliot Moswane	011 878-3389	PO Box 678, Germiston , Johannesburg, 1400	Limpopo
ACTOM	John Williams	011 820-5097	PO Box 13024, Knights , Boksburg, 1413	Highveld
ADC Energy	Trevor Reddy	011 397-8168	PO Box 1365, Edenvale, 1609	Highveld
Advanced Terminations and Joints	Johnny Coertze	012 661-3677	Suite 383, Private Bag X 132 , Centurion, 0046	Highveld
Afritek	Neelesh Pema	011 316-7512	PO Box 980, Olifantsfontein, 1665	Highveld
Aggreko	Tony Hamilton	011 357-8900	16B Axle Drive, Unit 2 Poplar Place Unit 2, Olifantsfontein, 1666	International
AJ Charnaud & Co.	Andre de Wet	011 794-6040	PO Box 4332, Honeydew, 2040	Highveld
Alectrix	Ingrid Beimel	021 790-1665	PO Box 26120, Hout Bay, 7872	Highveld
Aleng Electrical Engineers	Guy-Guy Palmi	011 805-0391	Unit 11, Ledgem Office Park, Halfway House, 1685	Highveld
Allbro	Quintin Lamprecht	011 894-8341	PO Box 6699, Dunswart, 1508	Highveld
Altech Alcom Matomo	Noël Watermeyer	011 235-7678	7 Autumn Rd, Rivonia, 2128	Highveld
ARB Electrical Wholesalers	Scott Morrison	031 910-0200	10 Daniel Road, Benrose, 2094	KwaZulu Natal
Ballenden & Robb SA	Hendrin Germishuys	041 581-2262	PO Box 955, Port Elizabeth, 6000	Eastern Cape
Bayete Capital	Lucas Oberholzer	087 700-8332	PO Box 782090, Sandton, 2146	Highveld
BDE Consulting Engineers	Daniel de Vries	044 801-9700	PO Box 1862, George, 6530	Good Hope
Beka-Schréder	Gordon Arons	011 238-0021	PO Box 120, Olifantsfontein, 1665	Highveld
Bigen Africa Services	Johan Pieters	012 842-8700	PO Box 29, Innovation Hub, Pretoria, 0087	Highveld
BVI Consulting Engineers	Chris Botha	054 337-6600	PO Box 115, Upington, 8800	Cape Midlands
Carifro Consulting Engineers	Likhaya Nkonki	041 392-9898	PO Box 35091, Newtown Park, Port Elizabeth, 6055	Eastern Cape
CBI Electric: African Cables	Jonnie Badenhorst	016 430-6000	PO Box 172, Vereeniging, 1930	Highveld
CCG Cable Terminations	Arthur Cameron	011 394-2020	PO Box 192, Kempton Park, 1619	Highveld
CED - Consolidated Electrical Distributor	Danie Esterhuizen	011 314-8869	PO Box 890, Midstream Estate, 1692	Highveld
Chopper Worx	Deon Rossouw	011 021-9414	PO Box 1222, Lanseria, 1748	Highveld
Clinkscales Maughan-Brown (South)	Pierre Conradie	044 874-1511	PO Box 2551, George, 6530	Good Hope
Cochrane Steel Products	Alexander Richard Cochrane	011 394-1788	125 Fitter Road, Spartan, Kempton Park, 1619	Highveld
Conlog	Kim Terblanche	031 268-1111	PO Box 2332, Durban, 4000	KwaZulu Natal
Consolidated Power Projects Shared Services	Amit Ramkissoon	011 805-4281	Private Bag X42, Halfway House, Midrand, 1685	Highveld
Contour Technology	Sagie Moodley	031 266-9746	PO Box 37730, Overport, 4067	Main
CT LAB	Willie van Wyk	021 880-9915	PO Box 897, Stellenbosch, 7599	Good Hope
CTC Global	Wynand de Lange	073 344-2449	PO Box 14059, Zuurfontein, Vanderbijlpark, 1912	Eastern Cape
CU AL Engineering	Andrew Walsh	031 569-1242	PO Box 202079, Durban North, 4016	Highveld
Cullin Africa	Krish Chetty	011 848-1400	PO Box 78, Noordwyk, 1687	Highveld
De Villiers & Moore	Adrian Silberbauer	021 976-3087	PO Box 472, Durbanville, Cape Town, 7551	Good Hope
Delta Energy & Communications	Tamaryn Tesselaar	021 276-1251	First Floor, 71 Waterkant Street, Cape Town, 8000	Good Hope
Dihlase Consulting Engineers	Stephen Ngamlane	051 447-1636	Suite 258, Private Bag X01, Brandhof, 9324	Free State
DIPRO Consulting	Ivica Debeljkovic	011 787-3835	PO Box 131, Hurlingham View, Johannesburg, 2070	Highveld
Divaine Growth Solutions	Yolanda Ngalwana-Mabuto	021 524-2049	PO Box 2100, Bellville, 7535	Good Hope
Doble Engineering Africa	Luwendran Moodley	031 266-2920	PO Box 1150, Wandsbeck, Durban, 3631	KwaZulu Natal
DSG-Canusa GmbH	Paul Sheridan	+44 1752 209880	DSG Canusa,Bergstrand House, Parkwood Close,Broadley Industrial Park, England, PL6 7SG	International
Eaton Electric SA	Nontuthuko Mkize	011 824-7400	PO Box 019, Wadeville, 9302	Highveld
Eberhardt-Martin	Gerard Connolly	011 288-0034	PO Box 58365, Post Point Deleray, Newlands, 2114	Highveld
ECA (SA)	Cecil Lancaster	012 342-3358	PO Box 12011, Hatfield, 0028	Highveld
Edge Line Engineering	Gary Shear	011 680-5492	PO Box 2053, Mondeor, Johannesburg, 2110	Highveld
EE Publishers	Roger Lilley	011 543-7000	PO Box 458, Muldersdrift, 1747	Highveld
Electro Inductive Industries	Abduraghmaan Adams	021 980-9600	PO Box 1454, Brackenfell, Cape Town, 7561	Good Hope
e-Lek Engineering	Leon Knoll	012 349-2220	PO Box 70577, The Willows, 0041	Highveld
Element Consulting Engineers	Christo Botha	021 975-1718	PO Box 1142, Durbanville, 7551	Good Hope
Elexpert	Hendrik Barnard	011 787-7566	166 Oak ave, Ferndale, Randburg, 2125	Highveld
Elster Solutions	Simon Dart	011 699-0420	PO Box 1603, Ferndale, 2160	Highveld
Experbuy-GE Grid Solutions	Gert Booysen	082 665-5090	PO Box 787122, Sandton, 2146	Highveld
Eyo Bantu Professional Services	Mike Brown	043 726-2726	PO Box 19803, Tecoma, East London, 5241	Eastern Cape
Farad	Peter Gerber	011 726-4090	PO Box 31220, Braamfontein, 2017	Highveld
Flo Specialized Product Solutions	Fabian Oostendorp	021 982-7551	PO Box 5101, Kraaifontein North, 7572	Good Hope
Genlux a division of Actom	Sello Tsoai	011 825-3144	PO Box 1183, Germiston, 1400	Highveld

AMEU Affiliate Members

Organisation	Name	Phone	Postal address	Branch
GIBB	Paul Fitzsimons	011 519-4600	PO Box 2700, Rivonia, 2128	Highveld
GLS Consulting	Jayesh Ranchod	011 417-8687	PO Box 59, Bruma, 2026	Highveld
Grace Innovative Solutions	Deon Reyneke	071 606-7951	PO Box 555, Stilfontein, 2551	Highveld
Gubela Trading	Zanele Njova	033 345-3026	PO Box 389, New Germany, 3610	KwaZulu Natal
H.V. Test	Ron Goodwin	011 883-2148	PO Box 651287, Benmore, 2010	Highveld
Hellermann Tyton	Claude Middleton	011 879-6600	Private Bag x 158, Rivonia, 2128	Highveld
Hexing Electrical SA	Desmond Shongwe	011 078-0400	10 Saddle Road, Woodmead Office Park, Woodmead, 2191	Highveld
I.B Mcintyre & Co – Master Lock	Gregory Slater	021 508-1250	PO Box 342, Maitland, 7404	Good Hope
ID2	Phillip Loots	012 470-2200	PO Box 72614, Lynwood Ridge, Pretoria, 0040	Highveld
Idube Electrical	Keith Erwin	011 397-8281	PO Box 15474, Lambton, 1414	Highveld
Igoda Projects	TC Madikane	031 536-7300	PO BOX 1907, Durban, 4000	KwaZulu Natal
Imvuselelo Consultants	Francois van Wyk	031 266-2707	PO Box 698, Westville, 3630	KwaZulu Natal
Infraset (A Business Unit of Aveng Africa	Charlene Soupen	011 813-2340	PO Box 365, Brakpan, 1540	Highveld
Ingeteam	Tonzana Mwamuka	011 314-3190	PO Box 543, Halfway House, 1685	Highveld
Inspired Interfaces	Tom Phillips	031 765-6650	PO BOX 967, Hillcrest, 3650	KwaZulu Natal
Iso-Tech Systems	Ben Wagner	011 466-3701	PO Box 13442, Vorna Valley, 1686	Highveld
iX Engineers	Durr Pieters	021 912-3000	PO Box 398, Bellville, 7535	Good Hope
Izembe Technologies	Sipho Mthembu	012 667-1530	PO Box 10514, Centurion, 7181	Highveld
Izingodla Engineering	Sikhumbuzo Nxumalo	031 701-7552	PO Box 2651, Pinetown, 3600	KwaZulu Natal
JoCastro	Miklos de Castro	021 577-1602	PO Box 1548, Dassenberg, 7350	Good Hope
KBK Power Solutions	Fred Peters	031 782-1329	PO Box 133, Cato Ridge, 3680	KwaZulu Natal
Kirkwall Holdings SA	Peter Horn	011 914-2395	PO Box 8053, Edenglen, 1613	Highveld
KoCos Measurement & Control	Hein Erwin	021 982-0016	PO Box 3585, Durbanville, 7551	Good Hope
Kopani Utility Services	Pedro van Soest	021 914-9666	1st Floor Riverside Place, Tygerwaterfront – SouthGate, Bellville, 8000	Good Hope
Landis + Gyr	Nisha Chetty	012 645-3117	PO Box 4052, The Reeds, Pretoria, 0185	Highveld
LH Marthinusen (a division of ACTOM	David Sullivan	011 615-6722	PO Box 27440, Benrose, 2011	Highveld
Lighting Structures	William Brough	087 310-1000	PO Box 1592, Nigel, 1490	Highveld
Lowfoot Inc.	Philip Playfair	+416 5643144	585 Dundas St E, Toronto, ON M5A 2B7	International
Lucy Electric South Africa	Richard St. John	011 025-7490	PO Box 1078, Honeydew, Johnnesburg, 2040	Highveld
Lyners	Theo Potgieter	021 914-0300	PO Box 4901, Tygervalley, 7535	Good Hope
Lyon & Vennote	M Lyon	016 981-6270	Posbus 3925, Vanderbijlpark, 1900	Highveld
Machine Assesment & Reliability Technology	Kim Dare	011 848-6940	6 Elgin Village, The Willows Estate, Windsor West, 2194	Highveld
Malesela Taihan Electric Cable	Eurika de Lange	016 450-8200	PO Box 1643, Vereeniging, 1930	Highveld
Manelec Services	Dale Liebenberg	041 581-2262	PO Box 955, Port Elizabeth, 6000	Eastern Cape
Matjato Solutions	Donovan Grove	011 453-1177	PO Box 752231, Bedford Gardens, 2047	Highveld
Matleng Energy Solutions	Nelisiwe Magubane	010 035-0230	PO Box 1444, Gallo Manor, 2052	Highveld
McWade Productions	Marc Hindle	011 316-2262	PO Box 142, Olifantsfontein, 1665	Highveld
Medupe Distributors	Lemao Motaung	011 397-2913	PO Box 966, Isando, 1600	Highveld
Megger Limited	Nathaniel Folscher	011 391-3832	PO BOX 6910, Birchleigh, 1618	Highveld
Metindustrial t/a First National Battery	Desegan Govindsamy	031 502-4227	PO Box 5015, Benoni, 1500	KwaZulu Natal
Metro Prepaid	Simon Tippet	021 593-6224	Unit 7-8, The Old Timber Yard, Maitland, 7405	Good Hope
Motla Consulting Engineers	George Lotter	018 474-9000	PO Box 30, Robertson, 6705	Good Hope
Mott MacDonald Africa	Jason Rowan	011 519-0000	359 Rivonina Boulevard, Rivonia, 2128	Highveld
Musco Lighting	Derek Field	031 569-2129	PO Box 201165, Durban North, 1490	KwaZulu Natal
Netelek	Jason Moodley	012 804-7815	PO Box 73130, Lynnwoodridge, 0046	Highveld
Nordland	Raymond Nel	011 662-4300	PO Box 522, Muldersdrift, 1747	Highveld
Ntamo Technologies	Quentin Louw	0861 268-266	23 Chasewater Street, New Redruth, Alberton, 1449	Highveld
Nynas South Africa	Alistair Meyer	011 675-1774	Suite 550, Private Bag X09, Weltevreden Park, 1715	Good Hope
Ompetha Power Projects	Johan van Staden	011 784-0170	PO Box 650187, Benmore, 2010	Highveld
Ontec Systems	Ivar Kilian	021 928-1700	PO Box 4059, Tygervalley, 7536	Main
Optron	Sean Dane	012 683-4500	PO Box 7911, Centurion, 0046	Highveld
Patch Industrial Supplies & Consulting	Michael Tyszowiecki	021 906-0600	PO Box 5123, Tyger Valley, 7532	Good Hope
PEC Utility Management	Frikkie Nel	021 948-0225	PO Box 3157, Durbanville, 7551	Good Hope
Pendo Energy Solutions	Rudolph Evert	010 035-0232	PO Box 1444, Gallo Manor, 2052	Highveld
PH Marketing	Ashwin Dhawakieram	011 867 6767	PO Box 1925, Mulbarton, 2059	Highveld
Philips Lighting South Africa	Reggie Nxumalo	011 471 5000	PO Box 58088, Newville, Johannesburg, 2114	Eastern Cape
Pienaar & Erwee Engineers	Johann Erwee	012 998-5219	PO Box 1831, Brooklyn Square, 0075	Highveld
Pofu Supply On Demand	Angeline Mabena	011 047-1681	13 Tamarisk Street, Ormonde Ext1, Johannesburg, 2091	Highveld
Poly Box	Peter Willers	021 386-5777	PO Box 51578, Waterfront, 8002	Good Hope
Power Motla Innolumis	Francois van Tonder	011 234-0008	Posnet Suite 148, Private Bag X75, Bryanston, 2021	Highveld
Power Measurement & Distribution	Johan de Klerk	044 873-0762	PO Box 4700, George East, 6539	Good Hope

AMEU Affiliate Members

Organisation	Name	Phone	Postal address	Branch
Power Process Systems	Benjamin Roode	086 177-7769	PO Box 4172, Southgate, 2082	Highveld
Powertech Transformers	Mariaan Irwin	012 318-9735	PO Box 691, Pretoria, 0001	Highveld
Powerx	Derek Bottle	011 268-6735	301 3rd Floor, The Firs, Rosebank, 2196	Highveld
Pragma Africa	Nanette van Rensburg	011 848-6940	PO Box 3971, Tygervalley, 7536	Good Hope
Progressive Energy	Greg Schaufelbuhl	021 511-5580	PO Box 495, Paarden Eiland, 7420	Good Hope
PSW Consulting Engineers	Juan-Dirk Voigt	012 349-2253	PO Box 146, Persequor Park, Pretoria, 0020	Highveld
Pure Energy Lighting Consultants	David Mokoka	011 728-1249	PO Box 92516, Norwood, Johannesburg, 2117	Highveld
Pure Light Consortium	Felicity Barker	0861 688-688	31 Gold Street, Northgate Business Park, Cape Town, 8000	Good Hope
Qaphela Risk Services	Jannie Thompson	011 453-1177	PO Box 752231, Bedford Gardens, 2047	Highveld
Romika Projects	Mirriam Rampopo	072 336-9582	PO Box 522, Muldersdrift, 1747	Highveld
Regent Lighting Solutions	Randal Wahl	011 474-0220	PO Box 58176, Newville, Johannesburg, 2114	Main
Reinhausen South Africa	Kobus de Villiers	011 835-2077	PO Box 1395, Southdale, 2135	Highveld
Remote Metering Solutions	Francois Conradie	012 001-3600	PO Box 110, Persequor Park, Pretoria, 0020	Highveld
Revive Electrical Transformers	Dharmalingum Padayachee	011 613-1508	PO Box 83334, South Hills, Johannesburg, 2136	Highveld
Rocla	Kevin West	011 670-7600	PO Box 92, Roodepoort, 1725	Highveld
RPS Ilangabi	Regis Masuku	031 266-9505	PO Box 1670, Westville, 3630	KwaZulu Natal
Rural Maintenance	Jason Moodley	086 187-8725	99 Fascia Street, Silvertondale, Pretoria, 0008	Mpumalanga
RWW Engineering	Kyle Lass	011 433-8003	PO Box 2042, Southdale, 2135	Highveld
SABS Commercial	Auxilia Munhutu	011 238-2308	13 Byron Place, Tulisa Park, Johannesburg, 2197	Highveld
SABS Standards Division	Mogomotsi Motaung	012 428-6613	Private Bag X191, Pretoria, 0001	Highveld
Schneider Electric	Brighton Mwarehwa	011 254-6400	1 Riverview Office Park, Janadel Avenue, Midrand, 1685	Highveld
Sectional Poles	Morne van Zyl	012 348-8660	PO Box 17028, Groenkloof, 0027	Highveld
Siemens	Rodney Swartz	082 379-9989	Siemens House, 163 Uys Krige Drive, Cape Town, 7500	Good Hope
Siyaphambili Electrical & Industrial Supplies	Imtiaaz Kader	021 981-8556	Unit B25, Icon Business Park, Brackenfell, 7560	Good Hope
SMEC South Africa	Andre van der Walt	012 481-3800	PO Box 72927, Lynwood Ridge, 0040	Highveld
Specialist System Engineering	Gert Bezuidenhout	012 663-4331	PO Box 7170, Centurion, 0046	Highveld
Spectrum Communications	Kevin Clack	021 551-5800	PO Box 36900, Chempet, 7442	Good Hope
Spectrum Utility Management	Gustav Kritzinger	012 991-3122	PO Box 38525, Faerie Glen, 0043	Highveld
Spintelligent	Ricky Asher	021 700-3500	PO Box 321, Steenberg, 7947	Good Hope
Static Power (a div of Actom)	Nichola Fort	011 397-5316	PO Box 13424, Witfield, 1467	Highveld
Switchboard Manufacturers	Shane O' Reilly	031 508-1520	PO Box 40086, Red Hill, 4071	KwaZulu Natal
Syntell	Julia Williamson	021 710-2044	PO Box 30298, Tokai, 7966	Good Hope
SZZT South Africa	Paul Korb	034 375-7130	PO Box 2597, Newcastle, 2940	KwaZulu Natal
Tank Industries a Division of ATC	Adriaan Theron	021 700-4380	PO Box 9, Steenberg, 7947	Good Hope
Tavrida Electric Africa	Andrew Sibiya	011 914-2199	Postnet Suite 218, Private Post Bag x26, Sunninghill, 2072	Highveld
Terrapinn	Courtney Harty	011 516-4017	Private Bag x 65, Bryanston, 2021	Highveld
TGOOD Africa	Kobus Coetzer	011 064-1603	140A Kelvin Drive, Morningside Manor, Sandton, 2146	Highveld
The Electrical Contracting Board of SA	Tony McDonald	012 804-9652	PO Box 912479, Silverton, 0127	Highveld
TIS Invest	Sibusiso James Motaung	011 049-8682	Corporate Park North, 181 Roan Crescent, Midrand, 1685	Highveld
Trans Africa Projects	Gustav van der Merwe	011 207-7734	PO Box 6583, Halfway House, 1685	Highveld
Tridonic SA	Trevor Milne	011 923-9694	PO BOX 30542, Jetpark, 1469	Good Hope
Tritec Energy SA	Jo Dean	082 322-8918	PO Box 803, Northlands, 2116	Highveld
Ulungeni Consulting	Gerrie Breedt	035 792-1026	PO Box 1521, Empangeni, 3880	KwaZulu Natal
Universal Cables	Rudi Labuschagne	011 769-1394	PO Box 21335, Helderkruin, 1733	Highveld
Utilities World	Dave Mason	031 833-0100	Suite 701, 7 Floor Strauss Daly Building, Ridgeside Office Park, 4319	KwaZulu Natal
Utility Administration Services	Christo Myburgh	011 682-5000	PO Box 145802, Brakpan Gardens, 1452	Highveld
Verotest	Veronica Merry	011 805-8322	PO Box 50559, Randjiesfontein, 1683	Highveld
Vetasi	Bouke Spoelstra	012 348-4617	PO BOX 39178, Faerie Glen, 0043	Highveld
Voltano	Marius Schwartz	087 805-5218	Postnet Suite 293, Private Bag X1007, Lyttelton, 0140	Highveld
Voltex t/a Voltex Cape	Shawn Roets	021 530-3460	PO Box 291, Maitland, 7404	Good Hope
Wegezi Power Holdings	Lindokuhle Maseko	012 386-9490/1	PO Box 8402, Pretoria West, 0001	Highveld
Woodbeam	Blaize Magee	086 196-6323	PO Box 526, Modderfontein, 1645	Highveld
YeboTech	Grant Martin	021 713-7260	PO Box 30761, Tokai, 7966	Good Hope
Yem Yem Technologies	Thomas Bond	011 258-8968	Building 2, Country Club Estate, Woodmead, 2052	Highveld
Zamori Engineering Services	Charles Marthinus	012 543-3487	349 Borage Avenue, Annlin West, Pretoria, 0182	Highveld
Zest Weg Group Africa	Dillon Govender	011 723-6000	Private Bag X10011, Sandton, 2146	Highveld

AMEU Past Presidents

Date	Name	City
1915 – 1917	JH Dobson	Johannesburg
1917 – 1919	J Roberts	Durban
1919 – 1920	B Sankey	Port Elizabeth
1920 – 1922	TCW Dodd	Pretoria
1922 – 1924	GA Swingler	Cape Town
1924 – 1926	J Roberts	Durban
1926 – 1927	B Sankey	Johannesburg
1927 – 1929	J Mordy Lambe	East London
1929 – 1931	R Mcaulay	Bloemfontein
1931 – 1933	LL Horrel	Pretoria
1933 – 1934	LF Bickell	Port Elizabeth
1934 – 1935	AR Metelerkamp	Salisbury
1935 – 1936	GG Ewer	Pietermaritzburg
1936 – 1937	A Rodwell	Johannesburg
1937 – 1938	JH Gyles	Durban
1938 – 1939	HA Eastman	Cape Town
1939 – 1944	IJ Nicholson	Umtata
1944 – 1945	A Rodwell	Johannesburg
1945	JS Clinton	Salisbury
1945 – 1946	JW Phillips	Bulawayo
1946 – 1947	GJ Muller	Bloemfontein
1947 – 1948	C Kingsman	Durban

Date	Name	City
1948 – 1949	A Foden	East London
1949 – 1950	DA Bradley	Port Elizabeth
1950 – 1951	CR Halle	Pietermaritzburg
1951 – 1952	JC Downey	Cape Town
1952 – 1953	AR Sibson	Bulawayo
1953 – 1954	JC Fraser	Johannesburg
1954 – 1955	GJ Muller	Bloemfontein
1955 – 1956	DJ Hugo	Pretoria
1956 – 1957	JE Mitchell	Salisbury
1957 – 1958	JL van der Walt	Margate
1958 – 1959	CG Downie	Cape Town
1959 – 1960	RW Kane	Johannesburg
1960 – 1961	RMO Simpson	Durban
1961 – 1962	C Lombard	Livingstone
1962 – 1963	PA Giles	East London
1963 – 1964	JC Downey	Margate
1964 – 1965	RW Barton	Windhoek
1965 – 1967	D Murray-Knobbs	Port Elizabeth
1967	GC Theron	Lourenco Marques
1969 – 1971	HT Turner	Umtali
1971 – 1973	JK von Ahlften	Cape Town
1973 – 1975	JC Waddy	Pietermaritzburg

Date	Name	City
1975 – 1977	E de C Pretorius	Durban
1977 – 1979	KG Robson	East London
1979 – 1981	PJ Botes	Johannesburg
1981 – 1983	DH Fraser	Durban
1983 – 1985	W Barnard	Johannesburg
1985 – 1987	JA Loubser	Benoni
1987 – 1989	AHL Fortmann	Cape Town
1989 – 1991	FLU Daniels	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	Pietermaritzburg
2004 – 2006	D Potgieter	Polokwane
2006 – 2007	V Padayachee	Johannesburg
2007 – 2008	S Maphumulo	Durban
2008 – 2010	S Gourrah	East London
2010 – 2012	M Rhode	Stellenbosh
2012 – 2014	H Roos	Ekurhuleni
2014 – 2016	S Xulu	Johannesburg

AMEU Honorary Members

Period	Name
1915 – 1936	Dr. HJ van der Bijl J Roberts E Poole
1938	LL Horrel
1944	GH Swingler AT Rodwell
1950	Dr. JH Dobson
1951	HA Eastman
1955	W Ballad-Ellis JC Fraser C Kinsman
1956	WH Milton A Morton Jaffray Major SG Redman Clr. CEK Young
1957	DA Bradley
1958	Col. GG Ewer A Foden Clr. Halley
1960	Clr. FJ Castelyn Clr. LP Davies
1962	AR Simpson
1963	CG Downie JC Downey RW Kane
1965	G Muller
1967	Clr. JD Marais JR Telles
1969	W Beesley PA Giles D Murray-Nobbs EL Smith

Period	Name
1971	DJ Hugo ACT Frantz HT Turner R Leishman RMO Simpson W Rossler F Stephens JF Lategan
1973	RG Ewing
1975	Clr. HG Kipling C Lombard DC Plowden JG Wannenberg
1977	Dr. RL Straszacker AA Middlecote GC Theron JC Waddy
1979	RW Barton Clr. HJ Hugo
1981	JDN van Wyk Dr. RB Anderson J Morrison
1983	TC Marsh
1985	AA Weich KG Robson Clr. RL de Lange W Barnard
1987	AP Burger JC Dawson DH Fraser PC Palser
1989	PJ Botes MPP Clarke EG Davies JA Loubser

Period	Name
1993	FLU Daniel JE Heydenrych B van der Walt
1995	CE Adams B Madeley
1997	JD Algera HR Whitehead F van der Velde
1999	JG Malan CE Burchell
2003	AJ van der Merwe
2005	PE Fowles T van Niekerk J Ehrich
2007	DET Potgieter
2008	V Padayachee
2009	S Maphumulo JJG Nel
2010	O Bothma JE Coetzee RS Wallis
2011	M Carry D Louw H Roos S Gourrah
2012	Michael Rhode Paul Johnston Louis Steyn Ferdinand Diener Roy Wienand Jorge Pereira
2014	Joseph Renney Neil Ballantyne Pierre van den Heever
2015	Silas Zimu Gerrit Teunissen Len Richardson
2017	Stan Bridgens Dawie van Niekerk Sicelo Xulu

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Barend J de Lange	Jan Malan


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