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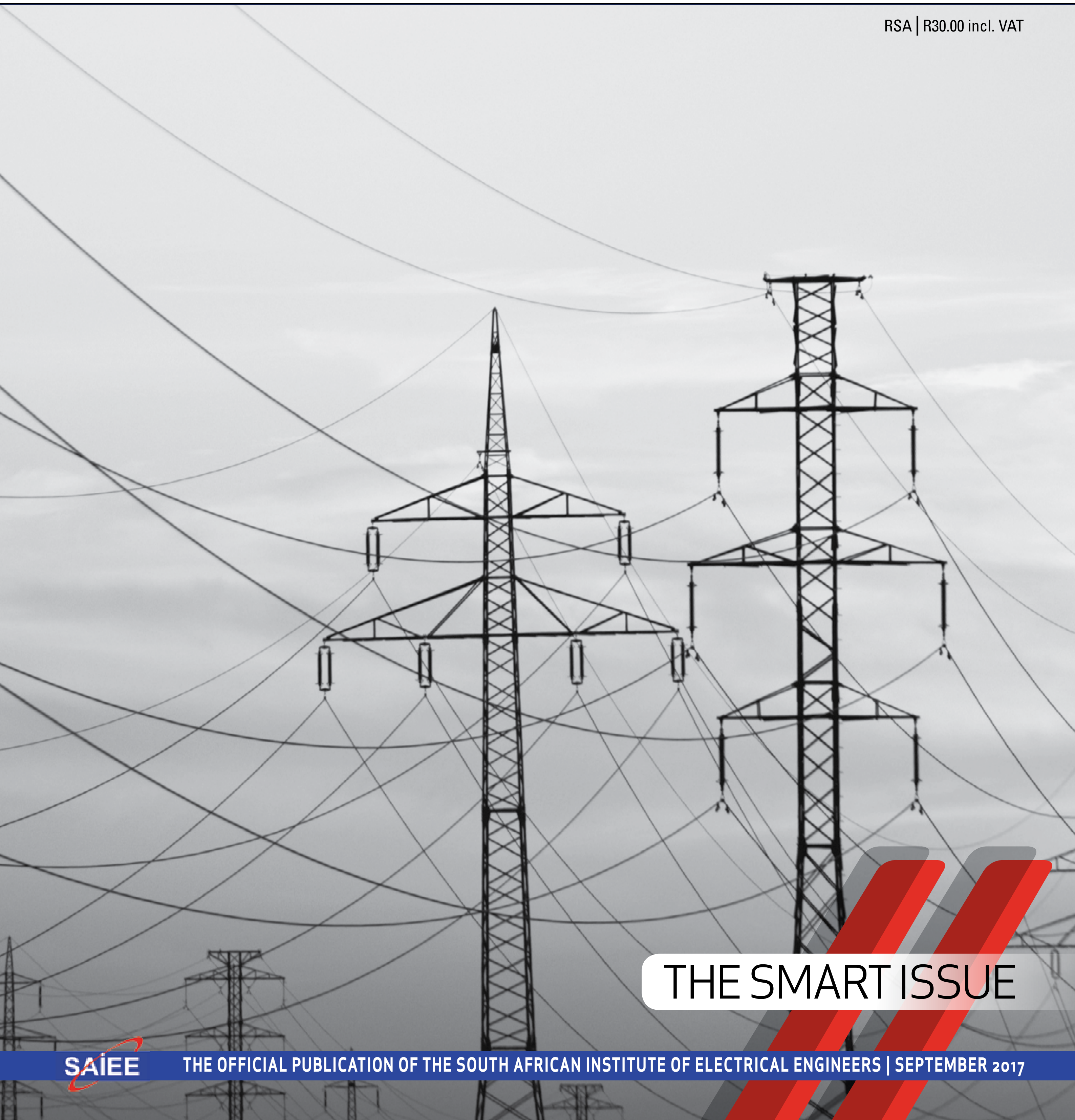
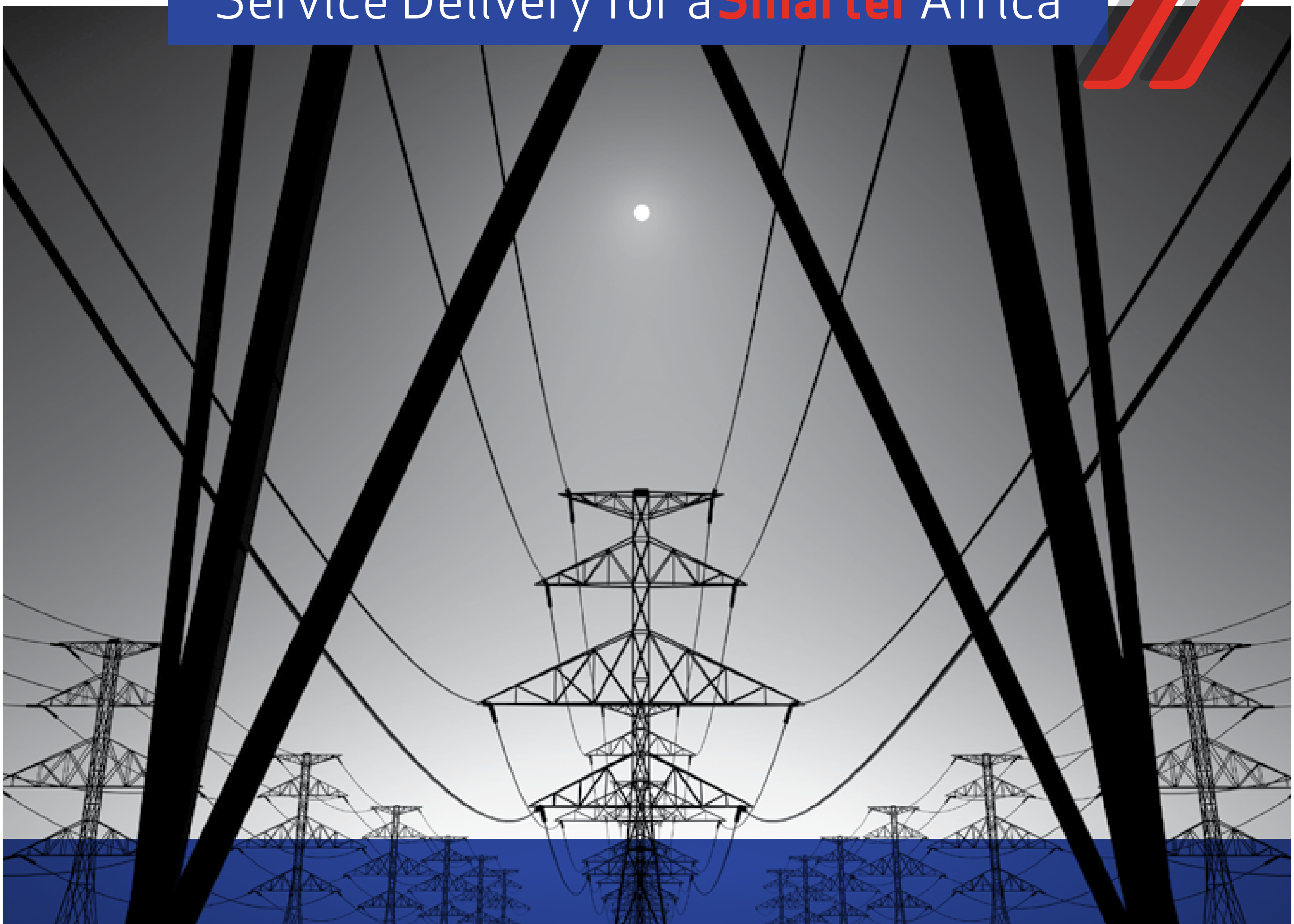


THE SMART ISSUE

SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | SEPTEMBER 2017



WE'RE PROUD TO WELCOME THIS YEAR'S SPEAKERS

PROF MASSOUD AMIN

KEYNOTE SPEAKER

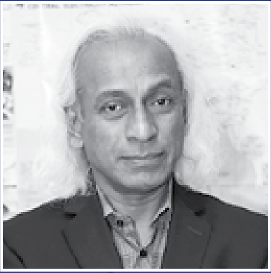
Professor Amin holds the Honeywell/H.W. Sweatt Chair in Technology Leadership at the University of Minnesota, and is also the Director of the Technological Leadership Institute (TLI) at the University.

Professor Amin is an expert in smart grids, dynamical systems and controls, critical infrastructure security, pivotal technologies, global S&T development, IP valuation and strategy, and teaches a number of courses both at undergraduate and post graduate level. His research focuses on two areas: 1) Global transition dynamics to enhance resilience, security and efficiency of complex dynamic systems, including national critical infrastructure for interdependent energy, computer networks, communications, transportation and economic systems; 2) Technology scanning, mapping and valuation. He pioneered research and development in smart grids, and since 2003 has given four briefings at the White House and nine Congressional briefings on smart grids

VALERIE-ANNE LENCZNAR

PLENARY SPEAKER

Valerie-Anne Lencznar is a communication (CELSA-Paris IV Sorbonne) and Executive MBA (HEC) graduate. She has worked and led as a Communication Director in various public structures. She joined the Energy sector 15 years ago as the Communications Director of a nuclear generation power plant, and she has worked on the expansion of the EDF Group in Poland and Hungary. Between 2009 and 2015 she was General Secretary of Inelfe, the Franco-Spanish joint venture dedicated to the construction of the underground electricity interconnection between Perpignan and Figueras, a world first, with a total budget of 700 million Euros. This project proceeds the setting up of smart grid transportation in Europe.



REJI KUMAR PILLAI

PLENARY SPEAKER

Reji is the President of the India Smart Grid Forum and Chairman of the Global Smart Grid Federation. He is an internationally renowned expert with over three decades of experience in the electricity sector in diverse functions covering the entire value chain across continents. He is spearheading a mission to leverage technology to transform the electric grid in India and light every home at affordable cost through sustainable developmental models. Reji played a pivotal role in the formulation of the Smart Grid Vision & Roadmap for India and the launch of a National Smart Grid Mission by the Government of India.

co-hosted by Eskom

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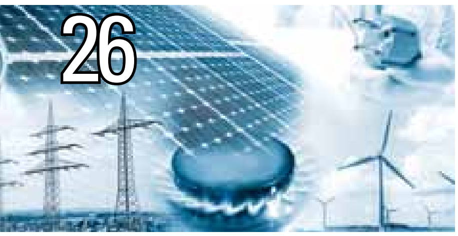

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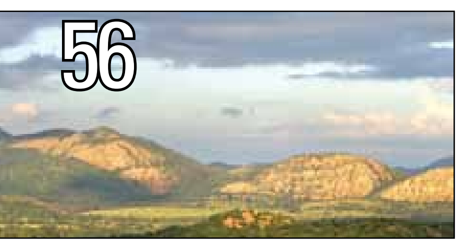

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Dear Reader,

This issue of the **watt**now magazine, is the "Smart" issue and it also serves as the programme of the 2017 SAIEE Smart Grid Conference.

In this issue, I feature four of the ±20 different papers that will be presented at the Smart Grid Conference: Page 18 features "The Electrification of Rural Areas through Micro-grids", which discusses a new electrification solution in order to light up Africa.

The CSIR has initiated an energy-autonomous program which will be implemented over the next few years. Read more on page 26.

Of course, the smart grid is nothing without connectivity - and with connectivity comes various risks, and therefore we feature a paper on Data Security. Read more on page 34.

Lightning is a natural occurrence, of which we have no control, but it has a serious effect on electrical grids; read the paper on page 42.

At the recent PowerGen Africa Conference, which took place in July 2017, SAIEE sponsored a prize for the best Gen X Paper, which was won by Moeketsi Tsosane of the Nelson Mandela Metropolitan University. This paper can be found on page 48.

May you enjoy a fabulous month of Spring and I hope to see you at the Smart Grid Conference.

Herewith the September issue, enjoy the read!

Visit www.saiee.org.za to answer the questions related to these articles to earn your CPD points.


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JACOB MACHINJIKE
2017 SAIEE PRESIDENT

The electric grid is one of the largest machines mankind has ever built. It has been constructed, operated, maintained and thus evolved over the past century. However, it will fundamentally change over the next decade or two. The advent of the smart grid will bring revolutionary change to every utility across the globe.

"How do we adapt our industry and skills into the future?"

It will shape the future of the electricity industry for decades to come. The advent of the Smart Grid provides a unique opportunity to make a difference to every citizen in our country and in the African continent.

It is important not to get caught up in definitions and models for the smart grid, there are simply too many which are too unique to different environments. The smart grid should rather be viewed as an exercise of a unique engineering effort and combination of standardized smart technologies to solve our local priorities.

South Africa, and Africa, is blessed with significant natural renewable energy resources such as solar and wind. The unique combination of smart technologies will aide to integrate these forms of generation, such as sensor data to forecast the dynamic generation capability, or integration of storage to alleviate variability and supply energy during peak periods.

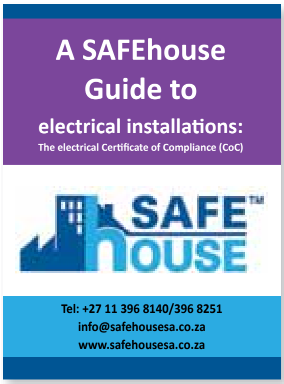
Skills in the industry will be changing dramatically. Consider our technical staff using a fluke meter today and an IP sniffer tomorrow. How do we adapt our industry and skills into the future?

Bid data, analytics and robotics provide levels of improved performance, efficiencies and significant cost savings will be passed onto our prosumers. The micro-grid concept will engineer a unique self-sustaining renewable solution for electrifying the 5,5 million citizens that live today without electricity. This can be replicated for the rest of the African continent.

Over the past 100 years, the centralised generation model has dominated the electricity landscape, with technologies over this time, produced mere evolutionary improvements. The monotony has not attracted the brightest engineering minds to the industry. However, the next decade, and decades to follow, will be the most exciting time to be involved in the power utility space. There are several smart technologies that promise to challenge the status quo and demolish the barriers to entry.

J Machinjike | SAIEE President 2017
Pr. Eng | FSAIEE

CAN YOU TRUST YOUR ELECTRICAL INSTALLATION?



Whether at home or at work, electricity is inherently dangerous. For this reason, electrical installations are subject to regulation in order to protect occupiers of buildings.

The governmental authority in this regard is the ***Department of Labour***. Its Certificate of Compliance (COC), completed by the electrical contractor, is designed to provide assurance of such protection.

For a number of reasons, users are not always protected in this way.

In the interests of users, SAFEhouse has produced a Guide to Electrical Installations, centred on the requirements of the Certificate of Compliance.

The guide also contains some guidelines for owners and occupiers of homes and other buildings.

This and other SAFEhouse guides can be downloaded free of charge from our website. Limited quantities are available in printed format.

Download **FREE** copies of SAFEhouse guides from

www.safehousesa.co.za

SAFEhouse members have signed a code of conduct: Your assurance of commitment to offer only safe electrical products and services.

SAFEhouse membership is suppliers' assurance to customers of responsible behaviour and of customers' safety as a priority. SAFEhouse members regulate themselves. SAFEhouse is primarily a communications association that informs users of safety requirements and occurrences of non-compliance with such requirements.

SAFE HOUSE™
Suppliers you can trust

As at 28/06/2017

The SAFEhouse Association is a non-profit, industry organisation committed to the fight against sub-standard, unsafe electrical products and services.

For more information contact:

Barry O'Leary: Tel: 011 396 8251 | Email: barry.oleary@safehousesa.co.za

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www.safehousesa.co.za

New appointments at DEHN Africa

Hannes Ackermann
Managing Director
DEHN Africa

Hano Oelofse
Technical Director
DEHN Africa

DEHN Africa (PTY) LTD has appointed a new Managing Director, Hannes Ackermann, and promoted incumbent Technical Manager Hano Oelofse to the position of Technical Director.

These recent appointments took place after DEHN Africa founder and former MD, Alexis Barwise, was promoted to director: Asia, Middle East and Africa (AMEA) at DEHN + SÖHNE in Neumarkt, Germany.

Ackermann assumed the position of Managing Director, effective 1 August 2017, having been previously employed by Endress+Hauser South Africa as its Africa Sales Manager.

Ackermann notes that DEHN + SÖHNE GmbH is a market leader in its industry, and the leadership team at DEHN Africa have an amazing entrepreneurial spirit and vision. *"I welcome the opportunity to take this four-year-old company - which is already doing very well – to even greater heights."*

Technical Director Hano Oelofse's promotion was also effective from 1 August. Oelofse says, *"In keeping with our rapid growth, DEHN Africa has created a DEHN technical business unit within the company to take us to the next level. We've also established a division called DEHNservices, which offers training, consulting services, support and testing."*

Ackermann concludes, *"At DEHN Africa, we are able to tap into more than 100 years of manufacturing experience, product development and technological evolutions. In addition, DEHN Africa boasts extensive application experience and the ability to provide up-to-date and modern technological solutions to our customers."*

KITE 2017 provides a comprehensive portal for industrial technology solutions

The KwaZulu-Natal Industrial Technology Exhibition (KITE), which took place from 26 to 28 July 2017 at the Durban Exhibition Centre, once again proved that it is undoubtedly the only place in KwaZulu-Natal to source and experience a comprehensive variety of industrial technology solutions under one roof.

With a total overall attendance of 4 470 of the country's industry professionals (97% from KwaZulu-Natal), KITE 2017 was lauded as the definitive interactive industrial technology equipment showcase.

"With an average of 1 289 visitors per day in 2015, compared to the daily average of 1 490 this year, all three days of the exhibition were extremely busy. The 150-plus exhibitors (up 30 exhibitors from 2015) welcomed visitors from across a number of industries and interestingly, 55% of all visitors had never attended KITE previously," says John Sterley, Portfolio Director at Specialised Exhibitions.

Feedback from the visitors clearly indicated their satisfaction for the wide selection of technology available. Kosheek Surajpal – Hulamin, says: *"We run a very large plant and because we are responsible for general maintenance, we need a variety of equipment. I am a regular visitor to KITE and find the show very informative. We found lots of new equipment and amassed a lot of valuable information."*

"We added a Propak Africa Pavilion to the 2017 event and this was very well received by the visitors. We have developed a great mix of visitor attractions and the free-to-attend SAIMechE Seminar Theatre, the MESA (Manufacturing Enterprise Solutions Association) special interest group and the Lifting Equipment Association of South Africa (LEEASA) conference were all extremely well attended." Sterley points out.

Marthinusen & Coutts Consolidates Presence As Preferred Electrical And Mechanical Services Provider

Marthinusen & Coutts is unique in that it is the only independently owned service provider that is capable of providing extensive maintenance, repair and special manufacturing solutions for all electrical and mechanical rotating machinery.

Marthinusen & Coutts, a division of ACTOM (Pty) Ltd, is consolidating its role as an integrated electrical and mechanical services provider across Africa, and internationally. Together with ACTOM Turbo Machines, the division offers the full range of maintenance, repair and special manufacturing services of electric motors, generators, turbo machinery and other high speed mechanical rotating equipment.

Richard Botton, Divisional CEO, Marthinusen & Coutts, says both Marthinusen & Coutts and ACTOM Turbo Machines have a long and proud history of serving customers on the continent. He ascribes the ongoing success to a combination of diligent planning, a culture of problem solving and providing innovative solutions; a sense of urgency, industry-leading skills, and having the necessary infrastructure and resources in place, both in South Africa and in strategic African countries.

Marthinusen & Coutts is unique in that it is the only independently owned service provider that is capable of providing extensive maintenance, repair and special manufacturing solutions for all electrical and mechanical rotating machinery.

"We are well positioned to carry out critical projects both in Africa and globally, having access to all our resources in South Africa as well as our well-equipped facility in Zambia, which provides immediate services to our customers in that region, with all the sought-after advantages of a local facility, plus the full backup of M&C and ACTOM's resources in South Africa," Botton says.
Marthinusen & Coutts has an extensive reference base of successfully completed projects, innovative maintenance solutions, record turnaround time breakdown repairs, and numerous on-site maintenance contracts.

He is quick to caution about the difficulties of providing maintenance services in African countries, with some companies lacking the necessary infrastructure, expertise and extensive experience that Marthinusen & Coutts is known for on complex projects and emergency repairs.

"A critical factor is that Marthinusen & Coutts has been involved in Africa for more than a decade, and as such have a sound knowledge of what it takes to deliver a quality solution to our customers in the countries in which we operate," Botton says. "It is our in-depth understanding of African conditions that allows our teams to get there, make a plan, manage and execute projects; and that is on an ongoing basis with numerous repeat customers."

The key differentiator for Marthinusen & Coutts is its rapid response time, inherent sense of urgency, culture of dedicated customer service and ability to mobilise quickly and efficiently in tackling critical projects. *"We understand our customers' business needs and that they cannot afford unscheduled downtime. Many of these projects are vital to ensure regular power supply to mining projects and other sectors, so our speed, understanding and service delivery are all essential,"* Botton says.

In addition, all Marthinusen & Coutts branches have direct access to their Centre of Excellence in Cleveland, Johannesburg. Critical equipment at this facility includes a 32-ton balancing machine, extensive testing capabilities and a fully equipped machine shop including CNC machines. *"While these advantages give us the competitive edge, Marthinusen & Coutts is also adept at thinking out of the box and renowned for its flexibility and ingenuity,"* Botton says.

"What gives us the leading edge in terms of these African contracts is that we can leverage the other divisions within the ACTOM Group to provide us with additional manufacturing capability, products, and expertise," he concludes.

The Trafo dry-type transformer is ideally suited to this application as it can be mounted inside the modular structure.

Dry-Type Transformers Ideal For Trend To Modular Sub-Stations

The introduction of Trafo dry-type transformers to the African market comes just at the right time for the end-user, as a number of industry sectors embrace the growing trend towards modularised substations.

"Due to the various benefits and the cost effectiveness of modular substations – which are fitted into either a marine container or a specially fabricated E-house – dry-type transformers are becoming more popular," says David Claassen, Managing Director of Trafo Power Solutions. *"The Trafo dry-type transformer is ideally suited to this application as it can be mounted inside the modular structure; this cannot be done with the traditional oil-filled transformer."*

Claassen highlights that safety is the prime concern in the design and construction of substations. Due to its design and the absence of oil as a coolant, the dry-type transformer is simple and safe, allowing extensive test work to be conducted with the modular unit prior to the full solution being sent to site. This in turn reduces the costs associated with site installation, assembly work and commissioning. *"There is an historical misconception that dry-type transformers are too large to be housed within a container, but this is not so,"* he says.

Including the dry-type transformer inside of the modularised substation has the cost saving benefit of eliminating the need for civils infrastructure that is needed for oil-filled transformers; these have to be located outside of the substation for safety reasons. This type of civils work includes foundations and a plinth on which the unit can stand, as well as special purpose bunding walls to contain oil leaks. This not only increases the cost of the installation, but lengthens the time frame in which the substation can become operational, and the cost of this additional civils infrastructure is also particularly high in the more remote areas of Africa.

The modern commercial facility builds on standards

Today, modern commercially-focussed facilities – from corporate office buildings to retail environments – make use of global technology standards. They ensure more efficient and flexible management of systems, are more cost effective and are infinitely more secure than trying to manage multiple disparate point solutions.

As the various solutions used by facilities (CCTV, HVAC, access control), etc continue to advance rapidly and begin to converge with IT and other external systems, the key to optimised facility and security management is having a standards-based Building Management System (BMS) platform in place. With the ability to integrate multiple systems comes greater control, and better management of risk.

The choice of BMS platform is key as it forms the foundation of, and is the command centre for, facility management. It needs to be able to access data from disparate systems, facilitate the analytics needed to make smarter decisions, and provide a central communication hub for systems. What is critical is that organisations select a world-class solution that is continuously evolving.

While there are pros and cons to the selection of all specialised systems, putting the right framework in place is half the battle.

To ensure that they have a range of features and functionality they need, as well as a future-proof platform that enables them to scale and grow, organisations would do well to seek out BMS providers that have a large client base reaching across multiple geographies and industries, and that have a strong track record with significant ongoing investment in R&D.

Security will also be a key factor to consider. With open systems, standards-based platforms make integration easier.

Cummins expands business in Zimbabwe and Mozambique

Cummins, a global power leader and corporation of complementary business units that design, manufacture, distribute and service diesel and natural gas engines and related technologies, is growing its business in Zimbabwe and Mozambique as market demands start showing signs of improvement.

Established in Zimbabwe in 1988, the company enjoys a solid and enviable reputation for its quality products over many years. Despite challenging market conditions during the past two decades, with markets dwindling and softening, innovative and resilient personnel have persevered and today the company shows signs of growth as the market slowly stirs and improves. Despite the country's lack of foreign direct investment, the company will invest in tooling to support growing its business needs in the power generation, mining, filtration and aftermarket businesses.

"We are here to support our customers, and will invest according to our business needs to ensure our customer requirements are met. Without our customers, we don't have a business," says recently appointed Director of Operations, Cummins Southern African Regional Office, Ms Racheal Njoroge.

Responsible for the leadership, operations and strategic direction for Cummins Zimbabwe and Mozambique, Njoroge has held a number of senior management positions within the global Cummins organization. Joining the company at its head office in Columbus, Indiana, in the USA as a Business Analyst Intern in the IT division in 2006; she saved the company a whopping $1million in her first year. Her success quickly led to several roles in the Global IT Strategy division, fast tracking and securing her career within the Group and ultimately bringing her back to the Continent of her birth.

Ms Racheal Njoroge
Director of Operations
Cummins Southern African Regional Office

2017 CESA Aon Engineering Excellence Awards winners

Consulting Engineers South Africa (CESA), supported by Aon South Africa, hosted a gala dinner in Midrand recently, to celebrate the 2017 CESA Aon Engineering Excellence Awards. These Awards recognize outstanding achievements in the engineering industry celebrating innovation, quality, outstanding workmanship and professionalism.

Lynne Pretorius, President of CESA states, *"Consulting Engineers are at the forefront of Infrastructure development and these awards bear witness to the pivotal role that Consulting Engineers, as trusted advisors and partners to our clients, play in the delivery of services to the people of South Africa and the African continent."*

"Given the pivotal role that CESA members have in the South African society and economy, these awards are about thanking all the participants for the role you play in our country's growth.

Most of all, the winning projects show us that South Africa still has so much to deliver and offer to its citizenry, and that the potential of the country that we love and call home will continue to require excellence that the Consulting Engineering industry has to offer."

Awards were handed out in the following categories: Young Engineer of the Year; Engineering Excellence for projects with a value of less than R50million; projects between R50million and R250million and for projects with a value of over R250million; Best International Project; Visionary Client of the Year; Mentor of the Year; Business Excellence; Mentoring Company of the Year; Publisher of the Year; Job Shadow Initiative; and Branch of the Year.

ELPA's first exam a great success

ELPA Certificated Installers with Trevor Manas, National Director, ELPA - middle front.

After the successful launch of the Earthing & Lightning Protection Association (ELPA) in Johannesburg in June 2017, ELPA has shown a remarkable growth with practitioners who wants to learn more about Lightning Protection joining.

ELPA Seminars have showcased that there has been limited knowledge shared on this topic up until now. Lightning is not dealt with at tertiary level as a topic in its own right; and tenders are being issued with the familiar clause 'Supply, design, install and certify the Lightning Protection System (LPS)' and without any Bill of Materials (BOM) or Design.

Contractors have indicated that they would welcome training in order to understand Lightning Protection, which is considered, by most, to be a 'mystical art'/science when in fact it is a skill/trade which can be taught. ELPA is proud to report that that they have presented their first Installation Accreditation Examination. Subsequently 120 people wrote the exam with 84 passing and are now Accredited Installers. Technical staff from across South Africa attended this training course, which indicates that there is a serious need for knowledge about Lightning Protection in the country.

"Very few people actually know how many lightning strikes, fatalities and how much damage we have in South Africa on an annual basis", says Trevor Manas, National Director of ELPA. *"We are entering into the lightning season in South Africa and consumers needs to be protected by professionals."*

Insurance companies pay out millions every year towards lightning damage claims which, could possibly, be minimised with better designed lightning protection systems.

From left: Trevor Manas, National Director, ELPA with Nicky Mokaa, Certificated ELPA Installer.

Due to popular demand, ELPA will be presenting another Installation Accrediation Examination on 18 - 19 October 2017 in Johannesburg. *"We will be running a Designer's & Tester's Exam early in 2018, so watch this space"*, concluded Manas.

For more information, visit www.elpasa.org.za

KZN Centre celebrates 60 year Anniversary

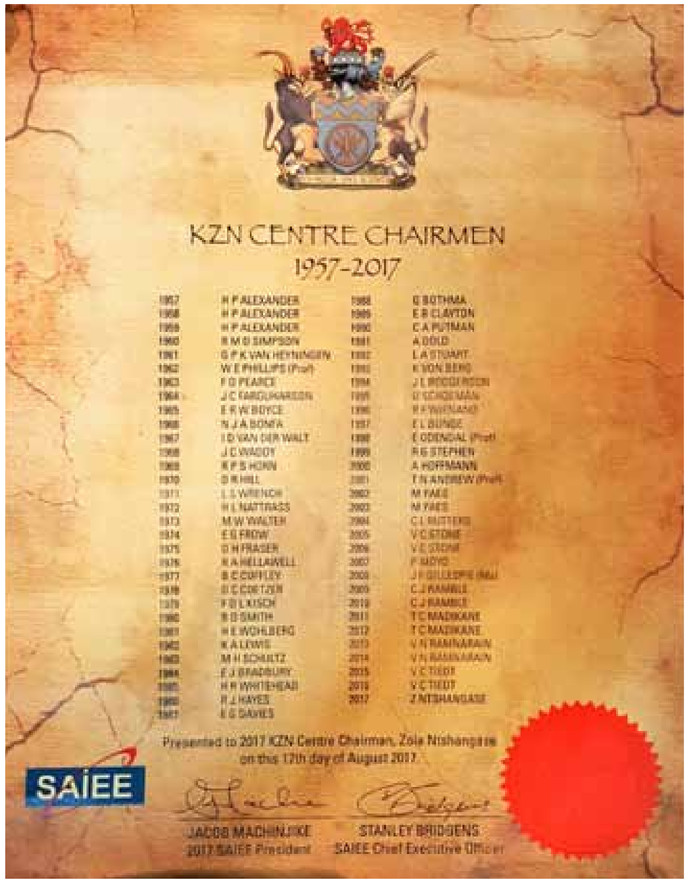
At a recent KwaZulu Natal Centre breakfast meeting, hosted by Zola Ntshangase, KZN Centre Chairman, the centre celebrated its 60th anniversary. This auspicious event was well attended. SAIEE members who attended include Jacob Machinjike, SAIEE President; members of Industry, Academia and the KZN Centre members.

Ntshangase welcomed members followed by the SAIEE President, Jacob Machinjike, presenting a commemoritive scroll to Ntshangase. *"This scroll has listed all the KZN Centre Chairmen's names from 1957 to 2017 and it is my honor to present Mr Ntshangase with this scroll"* said Machinjike. This scroll will find an honorary place in the SAIEE Museum at SAIEE Head Office in Johannesburg.

Chris Ramble (2009 KZN Centre Chairman), gave a historical overview of the KZN Centre, followed by Dr Rob Stephen (1999 KZN Centre Chairman) who gave a presentation on the 'Future Grid'.

Resham Singh, from eThekwini Electricity gave a presentation on Automation. Richard Ahlschlager (KZN Centre Committee Member) gave a presentation titled 'Teaching old dogs new tricks: How to prepare electrical engineers for the changing industry dynamics'.

"Here's wishing the KZN Centre all the best for the future and we are looking forward to the next 60 years", concluded Machinjike.



The commemorative scroll depicting KZN Chairmen from 1957 - 2017.

SAIEE KZN Centre Chairmen
From left: Roy Wienand (1996), Cyril Rutters (2004), Rob Stephen (1999), Chris Ramble (2009/2010), Zola Ntshangase (2017).

SAIEE President, Jacob Machinjike, handing the scroll to KZN Chairman, Zola Ntshangase.

Presenters:
From left: Resham Singh, Rob Stephen, Richard Ahlschlager participating in a Forum Panel Discussion.

Zola Ntshangase with Gill Nortier, KZN Centre Secretary.

IMAGINE A SMART-GRID WITHOUT **IT**?

IITPSA celebrates its 60th Anniversary

The Institute of IT Professionals (IITPSA), has been around for 60 years!

The institute was previously known as the Computer Society South Africa (CSSA) and was founded by Cecil John Aspinall (John). John was born in Pietermaritzburg in 1918. He started work at Hollerith Tabulators which later became one of the companies that merged to form IBM. In 1941, during WWII, John was inducted into the Royal Signal Corps. He was given permission to wear 'civvies' and joined Hut 7 at Bletchley Park where he oversaw the maintenance of the machines used to crack the Enigma code. He is credited with a modification to the machines that increased their speed.

John was demobbed in March 1945 and returned to South Africa where, in 1957, he founded the South African Computer Society (CSSA), along with several members of the British Computer Society who had relocated to South Africa after the war. CSSA was formally registered as a non-governmental organisation during 1958.

The first CSSA Annual Conference was run by Peter Aspinall of Strategic Business Services (no relation to John) and the Western Cape Branch in 1990; the theme was "Bridging the Gap". The success of this conference led to another nine years of conferences. The money raised from these events was used to employ a full-time office manager as well as to equip the offices with the latest equipment. The 10th CSSA Conference was in Durban in 1998 and the last one in Cape Town 1999.

In this day and age of rapidly evolving technology conference themes, names and types have been and gone. Tel.Com was another CSSA event born out of Telkom's annual Telematics Conference for Telkom's own engineers.

Alan Knott Craig of Telkom, contacted Peter Davies (then Chairman of the Data Com Sig) and Peter Aspinall to take over the annual event and open it to the public. This ran very successfully from 1995 to 2002 and became the largest telecoms event in Africa. In 2003, it was merged with Computer Faire and became FutureX which closed a few years ago.

Acknowledgment should be given to Martin Klein who, in addition to his duties as Chapter Chair (Durban), created the first Society website in 1997. Martin also started the Society's LinkedIn group, which remains today.

Other milestones in the 1990's, under the Presidency of Jonathan Miller, Peter Davies, and Peter Aspinall (among others) include:

- Recruiting the first Office Manager and equipping the office with computers using money we made from the CSSA annual conference and Tel.Com
- Establishing the International Computer Driver's Licence in South Africa
- Formalising the Computer Olympiad which was developed by Peter Waker into a major national annual event.

There have been three female presidents with Virginia Emily Marting taking the mantle in 1971. Fast forward to the 21st century when Moira de Roche served as President from 2004 to 2008. CSSA celebrated their 50th Anniversary in 2007, with some low-key events at different venues. CSSA acknowledged the anniversary by naming the two board rooms at the offices for John Aspinal and Moira de Roche. And more recently, Ulandi Exner was appointed as President in 2015.

Tony Parry was appointed as CSSA's first full-time CEO in 2007, and he still holds that position. It is under his stewardship that the Institute's membership and revenues have gone from strength to strength.

To show that the body is a professional one, and recognising that "computer" is a limiting term, CSSA changed its name to Institute of IT Professionals (IITPSA) in 2011. Since 2012, IITPSA has been recognised as a Professional Body by SAQA, and has also been accredited by International Federation of Information Processing's (IFIP) International Profession Practice Partnership (IP3) body in July 2013. The IP3 accreditation means that IITPSA's Professional Grade members are assessed against a global standard. IFIP is a global body created by UNESCO (United Nations Educational, Scientific and Cultural Organisation) in 1960.

IITPSA took over the reins of the Women in IT group, from Microsoft, last year.

Electrification of rural areas is an ongoing problem worldwide. Currently utility companies try to and extend their network to the rural areas to provide electricity after increasing their load capacity. This solution not only takes years to plan and implement but is also not cost effective or efficient. Therefore, there is a need for a new electrification solution. This paper proposes that a DC microgrid be used for the electrification of rural areas.

BY | EWALD ERASMUS & RAJ NAIDOO
DEPT. OF ELECTRICAL ELECTRONIC AND COMPUTER ENGINEERING | UNIVERSITY OF PRETORIA

The microgrid configuration was selected due to its promising expansion results, which has enabled many developed countries to expand their network capacity in an environmentally friendly as well as smart manner.

The DC topology was chosen because of its high efficiency and cost effective installation characteristics. In order to maximise the storage within the microgrid, nanogrids are proposed for individual households, meaning that each household will have its own supply as well as storage cells. The supply speculated by this paper is Solar PV; and was chosen because of the location of the population in question. In order to manage any excess power a localised storage system is proposed. This will act as a backup power supply when any of the lighting storage cells run out of capacity. This paper proposes that for lighting purposes, ultra-capacitors are used, while for general appliances, recycled 18650 cells* are used. Using the recycled 18650 cells not only reduces the cost of the total system but also provides a recycling

** In the world of rechargeable batteries, the lithium ion type last longer than most. Most 18650 cells are rated for between 300 and 500 cycles.*

The Electrification of Rural Areas through Microgrids

method for all the old 18650 cells that are expected to enter the market through the sales of Electric Vehicles. The process of recycling old Electric Vehicles battery banks for cells has many advantages. One significant advantage, excluding the positive environmental impact, is that the community can constantly increase their own capacity and hence easily expanding their own network. Further research in implementing this solution will occur.

INTRODUCTION

Ever since the discovery of electricity some 140 years ago, peoples' dependency on it has increased significantly and machines and systems have been electrified wherever possible. Electricity has become so important in our day to day lives, that now it is included in the human rights legislation of many countries [1]. However, it was estimated that in 2016, 1.2 billion people still had no access to electricity [2], not to mention the millions of individuals who have unreliable energy sources [2].

Traditionally, the problem to supply electricity to an area would be solved by extending an existing network into the

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rural areas. However this approach is only viable in more developed countries, where the supply is stable and can handle the additional loading. If an underdeveloped country attempted to implement this solution, their electrical network is likely to become unreliable, hindering their development even more.

Furthermore since 95% of those living without electricity are in underdeveloped countries [2] this is not a solution. A more viable solution, which has been mentioned repeatedly in literature [3]–[6], would be to use a microgrid for the specific rural area. Microgrids are not only being used in developing countries for electrification but also in developed countries to expand their network capacity [7].

The expansion projects in developed countries have primarily been focused on creating 'smart grids' with the inclusion of renewable energy sources for increased capacity. There are three main topologies which have been implemented: AC microgrids, DC microgrids and hybrid system microgrids. Currently the most common microgrid topology in use is the AC variation. This is due to its compatibility with current grid structures [8],[9]. However, electrification systems in buildings are slowly moving towards hybrid systems that can take advantage of the high efficiencies of the DC system, while still being able to power regular AC appliances [10].

DC microgrids are significantly more efficient than their AC counterpart, due to the lack of energy conversion links within the system and lower line losses [11]. Another significant advantage of the DC microgrid is that it "does not need to track the phase and frequency of the voltage, which greatly improves the controllability and reliability of the system" [12]. The lack of frequency monitoring also allows for additional sources to be easily integrated into the system. One organisation which is at the forefront of implementing hybrid systems in large buildings, is EMerge Alliance [13].

EMerge Alliance focuses on running dual AC and DC systems in buildings, where the DC system is used to power the lighting throughout the building and the AC system powers the regular office loads. The mission of EMerge Alliance is to improve the stability as well as the efficiency of the electrical grid both on the micro and macro scale through the implementation of standards which promote the use of DC microgrids.

DC MICROGRIDS

The implementation of a DC microgrid offers many advantages for first-time customers. The advantages for an urban and rural customer will differ slightly due to the appliances which the customer already owns. In general, DC microgrids offer the following advantages to their customers over their AC counterparts:

1. Lower raw material costs, as fewer conductors are required [14];
2. Lower installation costs due to reduced planning. Primarily caused by [14]:
   a. A lack of complex numbers in the analysis.
   b. A lack of susceptance and reluctance present in the system.
   c. No frequency or synchronisation problems with multiple sources;
3. Reduced system size. Caused by a lack of synchronising equipment and transformers needed for traditional AC systems [15];
4. Increased appliance efficiency. Avoiding the AC-to-DC conversions can save as much as 30% on a user's total energy bill [16]; and
5. Increased compatibility with renewable resources, therefore, reducing the environmental impact of a DC microgrid while at the same time allowing for more types of sources.

However, with that being said, the implementation of a DC system in an already urban environment is challenging due to its effect on the customer's lifestyle. Urban customers are affected far more than their rural counterparts as they will have to repurchase almost every appliance in the household. Rewiring is an option. However, this requires some technical know-how and thus cannot be expected from the average individual.

The construction of a DC microgrid can be done in three possible configurations: two-wire, three-wire and ring-shaped. Each configuration exists to serve a different sector in industry, however the two-wire variation is most commonly installed configuration [17]–[19]. The reason for this is due to its lower line losses and reduced installation cost [17]. However for DC microgrids with high capacity requirements, a three-wire system is recommended but balancing issues do exist [20].

ENERGY SOURCES

Distributed Energy Resources (DERs) are used in microgrids as power sources due to their size, controllability and mobility advantages [21]. Typical examples of DERs include diesel generators, micro turbines,

photovoltaic (PV) systems, fuel cells and wind turbines. The use of PV solar systems in microgrids is not uncommon. Developed countries have opted for their installation not only for their reduced environmental impact, but also because the implementation times of PV systems are significantly less than coal and nuclear fired power stations. These factors, along with the decreasing cost of solar PV panels as well as advancements in battery technology and power electronic devices make solar PV technology highly suitable for any microgrid, especially DC microgrids.

According to the International Energy Agency (IEA), "95% of those living without electricity are in countries in Sub-Saharan Africa and developing Asia" [2]. The potential for using PV solar systems in African countries is extremely high as the number of hours of sunshine in Africa is higher than any other continent. North-eastern Africa holds the record for the highest number of hours of sunshine a year, 4 300 hours.

This is in fact 97% of the total maximum hours possible [22]. Utilising this energy effectively would be impossible without some sort of energy storage device. The need for a storage device is not only there for night time usage but also to provide a buffer for heavy loading. In larger power grids, this storage is provided by the inertia of the generators. When a new load is connected to the system, the initial energy balance is satisfied by the system's inertia. The result of this loading causes a very slight change in the system frequency [21]. In microgrids the storage can be provided by batteries, ultra-capacitors, flywheels and in some instances water reservoirs. The batteries used can either be stand-alone banks, or the batteries such as those found in modern Electric Vehicles (EVs).

In urban environments the use of EVs is becoming increasingly more popular. Vehicle-to-Grid (V2G) technology has a great potential to improve the electrical stability of a country, however buy-in from the owners is required. The basic premise of a V2G system is to use the vehicle as a storage device; charging it when the overall demand on the grid is low and using the vehicle as a source when supply is low. The concept of using EVs as a storage device in a microgrid introduces a new topology or scale to the microgrid.

The placement of energy storage devices within every home through the use of EVs essentially makes each home its own microgrid or nanogrid within a microgrid [23]. This configuration maximises the number of energy storage devices as well as capacity present in the grid. In rural areas the use of EVs is not possible. However, the concept of creating many nano grids within a microgrid should be investigated. Figure 1 represents a generic nanogrid configuration which can be used within the rural community.

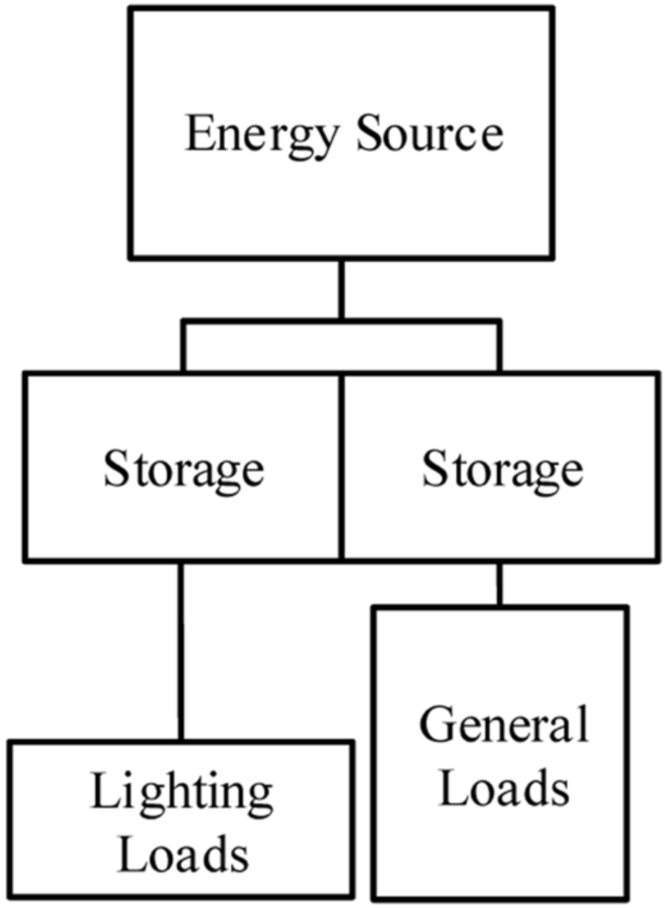

Figure 1: Nanogrid Configuration

It can be noted that the storage within the nanogrid is split into two separate units. The purpose of this to ensure that there is a dedicated supply for lighting at all times. This storage will take priority and charge first, ensuring that lighting is available every night. The proposed microgrid layout is shown in Figure 2. A localised storage unit will be used to store any excess charge which is available during the day. This will act as a backup power supply in the instance where one or more of the lighting storage banks need additional power.

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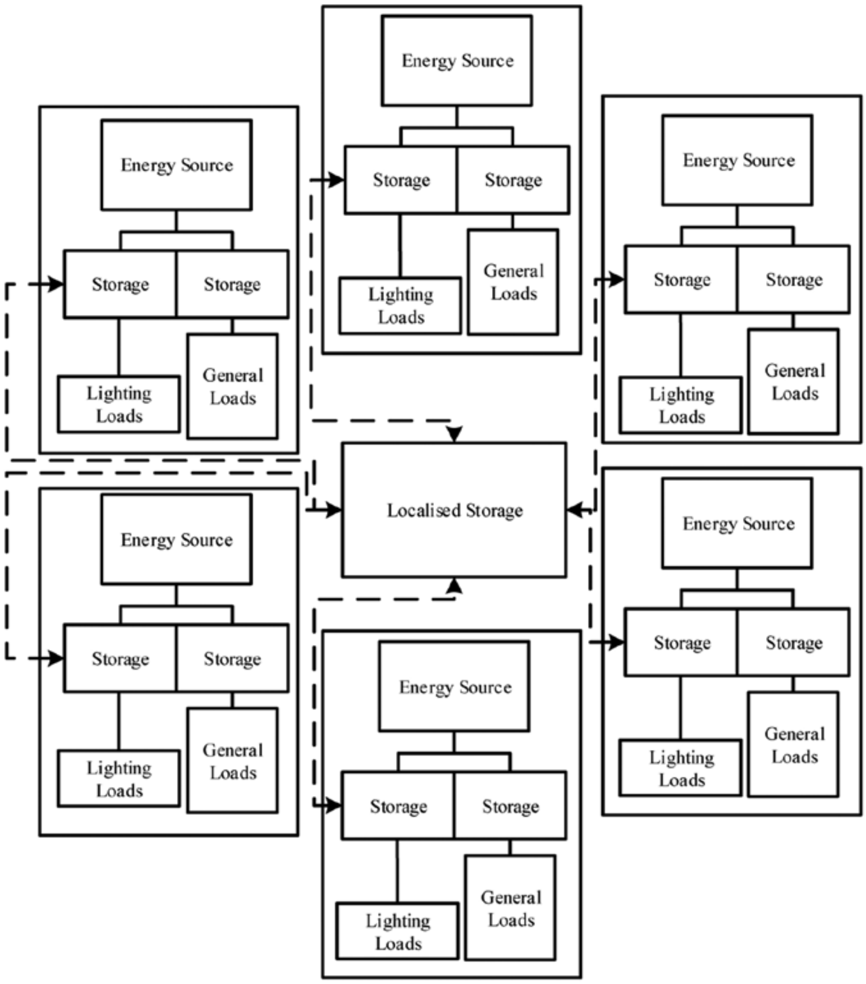

Figure 2: Microgrid Configuration

STORAGE SOLUTIONS

As shown in Figures 1 and 2, the storage used within the nanogrid is separated into two sections. The primary reason for this is so that lighting is guaranteed daily as well as in the long term plan. The storage which will be used for general loads and lighting loads will be different. The proposed storage for lighting will be ultra-capacitors, while batteries will be used for the general loads. The justification for using ultra-capacitors to power the lighting of a household is solely placed on the longevity of the storage device. Since no chemical action is involved in charging or discharging the ultra-capacitors, the effect is easily reversible with minimal degradation of the capacitor, even in deep discharge cycling.

The typical cycle life of ultra-capacitors is in the hundreds of thousands of cycles, while still producing extremely high efficiencies (84-97%) [24],[25]. The proposed storage for the general loads are recycled 18650 cells. With the popularity of 18650 cells growing, it is only logical to recycle them in a meaningful way. The process of determining the number of 18650 cells which will need recycling has been covered by [26]. The authors used the Annual Energy Outlook Data provided by the U.S Energy Information Administration (EIA) [27] to predict the number of EVs sold, shown in Fig.3. Using this data as well as their own algorithms they were able to predict the number of 18650 cells in every battery pack of every vehicle which is shown in Fig. 4 (within the figure EOL stands for End of Life). The prediction algorithms used within [26] took the following variables into account when determining the number of cells within every vehicle:

1. Vehicle electric range (Ri);
2. Vehicle consumption rate (C);
3. Battery efficiency (η);
4. Available energy of EV battery (Ai); and
5. Cell energy storage (Ecellj).

Since the publication of [26], new predictions have been made on the sales of EVs within the USA by the EIA [28], the updated prediction is shown in Fig. 5. The new prediction is significantly higher than the one made in 2012 with one noticeable change: the oil price does not dictate the number of EVs sold as drastically as it did in 2012. There are many factors which have led to this but the suspected cause is the launching and sale of EVs by Tesla and other big motor vehicle brands. With this increased prediction, even more lithium ion cells will enter the waste streams, hence making the need for recycling plans even more critical. The predictions made in [26] estimate that between 38% and 43% of the batteries in the waste stream will be type 2 EOL cells, where type 2 cells are defined as; “Those found in vehicles that reach their end-of-lives before their batteries” [26]. These type 2 cells are not only available from EVs but also old appliance batteries such

as laptops and power tools, and have already been used to create power walls in homes by DIY enthusiasts. The primary advantage of using recycled cells is the reduced cost as well as environmental impact. By allowing communities to create their own storage banks with recycled cells it not only solves the problem of how to recycle the battery banks from EVs but also empowers the community.

DISCUSSION AND CONCLUSION

The implementation of microgrids in developed countries has led to the building of smarter grids, while at the same time expanding their network in an environmentally friendly manner. The most efficient variant of the microgrid is a DC microgrid but it has been implemented less frequently in urban environments (developed communities) due to the lifestyle changes required of customers to use them. Rural customers however do not have these problems as they usually either only own DC appliances or do not own any electrical appliances. Since the vast majority of the "non-electrified" communities live in solar rich areas, solar PV systems will be used. Low cost MPPT converters are available to ensure that all the available power is extracted from the panels.

There is a need for a new electrification solution which will provide an efficient and effective supply of electricity to rural communities. Even though this problem has existed for many decades, the body of knowledge surrounding the use of a DC microgrid as a solution, is very limited. Consequently, the development of a DC microgrid based solution is suggested. The research will focus on an implementable design which includes the high-efficiency advantages of using a DC system while at the same time evaluating the feasibility of using a dual storage system of ultra-capacitors and recycled lithium ion batteries. This type of storage solution will not only provide a use for old EV battery cells but will also empower the community in a manner which is sustainable, providing long term solutions for both electricity and sustainability.

ACKNOWLEDGMENTS

The authors would like to thank SANEDI for the ongoing financial support.

REFERENCES

[1] S. Tully, "The Human Right to Access Electricity," Electr. J., vol. 19, no. 3, pp. 30–39, 2006.

[2] International Energy Agency, "World Energy Outlook 2016," 2016.

Figure 3: EV Sales forecasts for the USA, image taken from [26], but generated using [27].

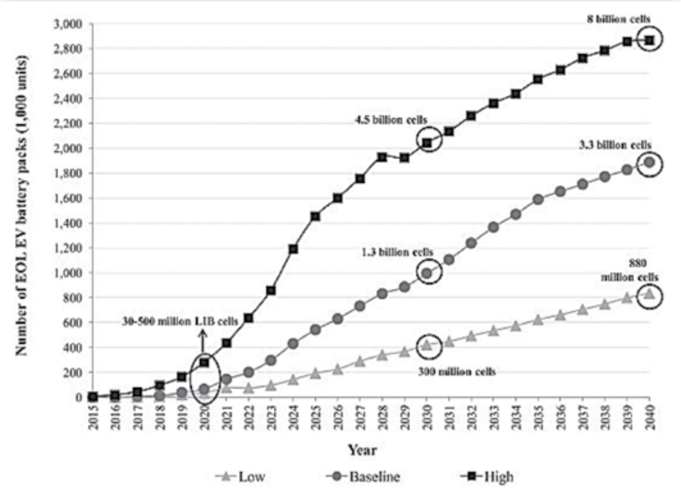

Figure 4: Number of 18650 cells generated from EV applications between 2015 and 2040 from [26].

Figure 5: EV Sales forecast for th USA from [28].

Microgrids

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[3] A. Yadoo, A. Gormally, and H. Cruickshank, "Low-carbon off-grid electrification for rural areas in the United Kingdom: Lessons from the developing world," Energy Policy, vol. 39, no. 10, pp. 6400– 6407, 2011.

[4] P. Raman, J. Murali, D. Sakthivadivel, and V. S. Vigneswaran, "Opportunities and challenges in setting up solar photo voltaic based micro grids for electrification in rural areas of India," Renew. Sustain. Energy Rev., vol. 16, no. 5, pp. 3320–3325, 2012.

[5] S. M. Kaplan, "Electric Power Transmission: Background and Policy Issues," Spec. Energy Environ. Policy, vol. 1, no. April, pp. 1–37, 2009.

[6] H. Camblong et al., "Micro-grids project, Part 1: Analysis of rural electrification with high content of renewable energy sources in Senegal," Renew. Energy, vol. 34, no. 10, pp. 2141–2150, 2009.

[7] I. Mitra, T. Degner, and M. Braun, "Distributed Generation and Microgrids for Small Island Electrification in Developing Countries : A Review," Sol. Energy Soc. India, vol. 18, no. 1, pp. 6–20, 2008.

[8] H. Lotfi, S. Member, A. Khodaei, and S. Member, "Hybrid AC / DC Microgrid Planning," IEEE Trans. Power Syst., vol. 8, no. 1, pp. 296– 304, 2016.

[9] H. Lotfi and A. Khodaei, "AC versus DC microgrid planning," IEEE Trans. Smart Grid, vol. PP, no. 99, pp. 296–304, 2015.

[10] P. C. Loh, D. Li, Y. K. Chai, and F. Blaabjerg, "Autonomous operation of hybrid microgrid with ac and dc subgrids," IEEE Trans. Power Electron., vol. 28, no. 5, pp. 2214–2223, 2013.

[11] M. Barnes et al., "Real-World MicroGrids-An Overview," 2007 IEEE Int. Conf. Syst. Syst. Eng., pp. 1–8, 2007.

[12] Z. H. Jian, Z. Y. He, J. Jia, and Y. Xie, "A review of control strategies for DC micro-grid," Proc. 2013 Int. Conf. Intell. Control Inf. Process. ICICIP 2013, vol., no., pp. 666–671, 2013.

[13] EMerge Alliance, "EMerge Alliance." [Online]. Available: http://www.emergealliance.org/. [Accessed: 04-May-2017].

[14] J. J. Justo, F. Mwasilu, J. Lee, and J. W. Jung, "AC-microgrids versus DC-microgrids with distributed energy resources: A review," Renew. Sustain. Energy Rev., vol. 24, no. August 2015, pp. 387–405, 2013.

[15] M. D. Ilic and J. Zaborszky, Dynamics and control of large electric power systems. Wiley New York, 2000.

[16] K. Garbesi, V. Vossos, and H. Shen, "Catalog of DC Appliances and Power Systems," -, vol., no. October, pp. 1–77, 2012.

[17] J. Li, X. Zhang, and W. Li, "an Efficient Wind-Photovoltaic Hybrid Generation System for Dc Micro-Grid," 8th Int. Conf. Adv. Power Syst. Control. Oper. Manag., pp. 1–6, 2009.

[18] M. G. Jahromi, G. Mirzaeva, S. D. Mitchell, and D. Gay, "DC power vs AC power for mobile mining equipment," 2014 IEEE Ind. Appl. Soc. Annu. Meet. IAS 2014, pp. 1–8, 2014.

[19] T. Dragi, X. Lu, J. C. Vasquez, and J. M. Guerrero, "DC Microgrids - Part II: A Review of Power Architectures, Applications, and Standardization Issues," IEEE Trans. Power Electron., vol. 31, no. 5, pp. 3528–3549, 2016.

[20] H. Kakigano, Y. Miura, and T. Ise, "Distribution voltage control for DC microgrids using fuzzy control and gain-scheduling technique," IEEE Trans. Power Electron., vol. 28, no. 5, pp. 2246–2258, 2013.

[21] H. Jiayi, J. Chuanwen, and X. Rong, "A review on distributed energy resources and MicroGrid," Renew. Sustain. Energy Rev., vol. 12, no. 9, pp. 2465–2476, 2008.

[22] I. Holford, The Guinness Book of Weather Facts and Feats. Guinness Superlatives, 1977.

[23] P. Robinson and Protonex, "Understanding Microgrids, Nanogrids, and Picogrids," Protonex. [Online]. Available: https://protonex.com/blog/understanding-microgrids-nanogrids-and- picogrids/. [Accessed: 18-Aug-2017].

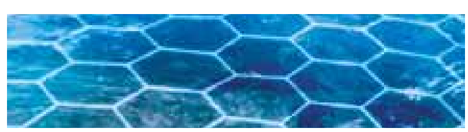
[24] H. Chen, T. N. Cong, W. Yang, C. Tan, Y. Li, and Y. Ding, "Progress in electrical energy storage system: A critical review," Prog. Nat. Sci., vol. 19, no. 3, pp. 291–312, 2009.

[25] S. C. Smith, P. K. Sen, and B. Kroposki, "Advancement of energy storage devices and applications in electrical power system," 2008 IEEE Power Energy Soc. Gen. Meet. - Convers. Deliv. Electr. Energy 21st Century, pp. 1–8, 2008.

[26] K. Richa, C. W. Babbitt, G. Gaustad, and X. Wang, "A future perspective on lithium-ion battery waste flows from electric vehicles," Resour. Conserv. Recycl., vol. 83, no. 2014, pp. 63–76, 2014.

[27] P. Viebahn et al., "Annual Energy Outlook 2012 with projections to 2035," Energy Policy, vol. 14, no. September, 2013.

[28] EIA, "Annual Energy Outlook 2017 with projections to 2050," pp. 1– 64, 2017. wn



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CSIR Energy Autonomous Campus Implementation of a Smart Microgrid

An Energy-Autonomous program has been initiated to make the Council for Scientific and Industrial Research's (CSIR's) main campus in Pretoria, South Africa, energy autonomous in a 5 to 8 year time horizon by supplying its energy from three primary renewable energy sources: solar, wind and biogas from biogenic waste.

BY I CLINTON CARTER-BROWN
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)

The power generation will be combined with demand-side management, energy-efficiency improvements and electricity and heat storage including the integration of electric and hydrogen-driven vehicles, power-to-liquid and power-to-gas processes. The other CSIR campuses across South Africa will gradually become part of the program, where in the long-term supply and demand will be virtually balanced across all CSIR campuses. This program will stand as a real-world research platform for designing and operating a primarily renewables-based energy system at lowest cost.

This platform will be used to demonstrate in a real-world setting of significant size how a future energy system, that is based on a combination of fluctuating and dispatchable renewables, can be designed and operated in the most cost-efficient manner in Africa. It will also at the same time allow technology demonstrators and technology development to aid the implementation of renewable energy systems in Africa. The aged campus electrical grid will be upgraded into a smart microgrid

RENEWABLE BASED MICROGRID OPPORTUNITIES IN AFRICA

RENEWABLE BASED ENERGY SYSTEM FUTURE

CSIR analysis of the outcomes of the South Africa Department of Energy Independent Power Producer (IPP) Program concludes that new wind/solar PV energy is now 40% cheaper than new coal in South Africa, as summarised in Figure 1 (outcomes of the renewable energy IPP procurement program and coal IPP procurement program) [1]. Furthermore the CSIR scenario modelling of the South African Integrated Resource Plan (IRP) shows that the lowest cost future power system is primarily renewable energy based [1].

In matured electricity markets, renewables compete with an existing, steady-state energy system, primarily acting as fuel savers for the existing thermal power generation fleet. The historical thermal generation incumbents have business models based on "large, central" and in general suffer in terms of decreasing market share as the penetration of renewable energy increases.

In emerging markets, the context and opportunity for renewable energy is different. Renewables can be at the core of the energy-system expansion to service the substantial backlog in energy access in a sustainable and cost effective manner, including the opportunity for standalone systems and microgrids [2, 3]. In developing economies:

- Renewables compete with historical thermal new-built options to meet growing electricity demand. The CSIR analysis of the South African power system shows that the most cost effective new build solution to meet forecasted electricity demand is a predominately renewable energy based system [1].
- Renewables are more than just fuel savers. The distributed nature of renewables changes the entire paradigm on which energy systems were traditionally planned, designed, built and operated [1, 2, 3].

Smart Microgrids

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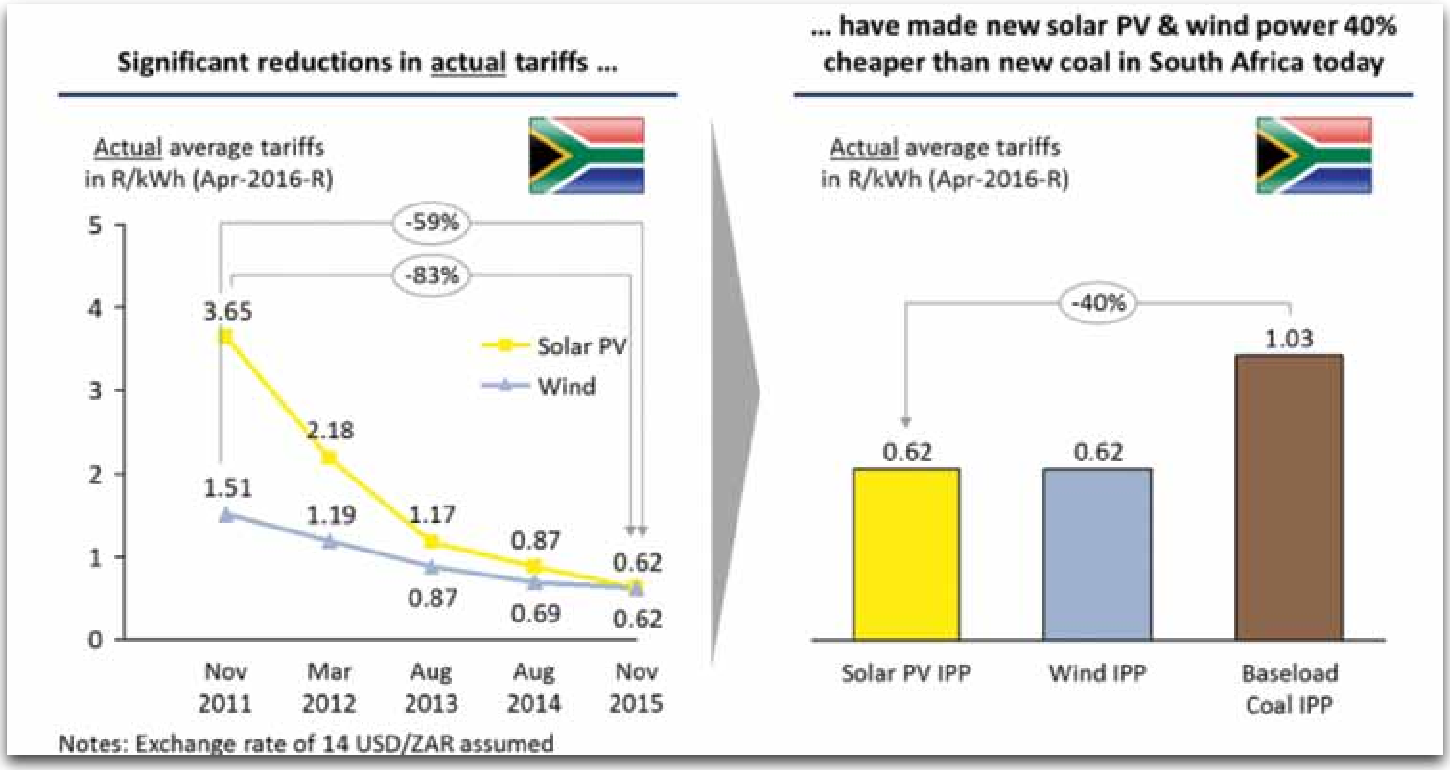

Figure 1: Comparison of new Wind/Solar tariffs with Coal in South Africa [1].

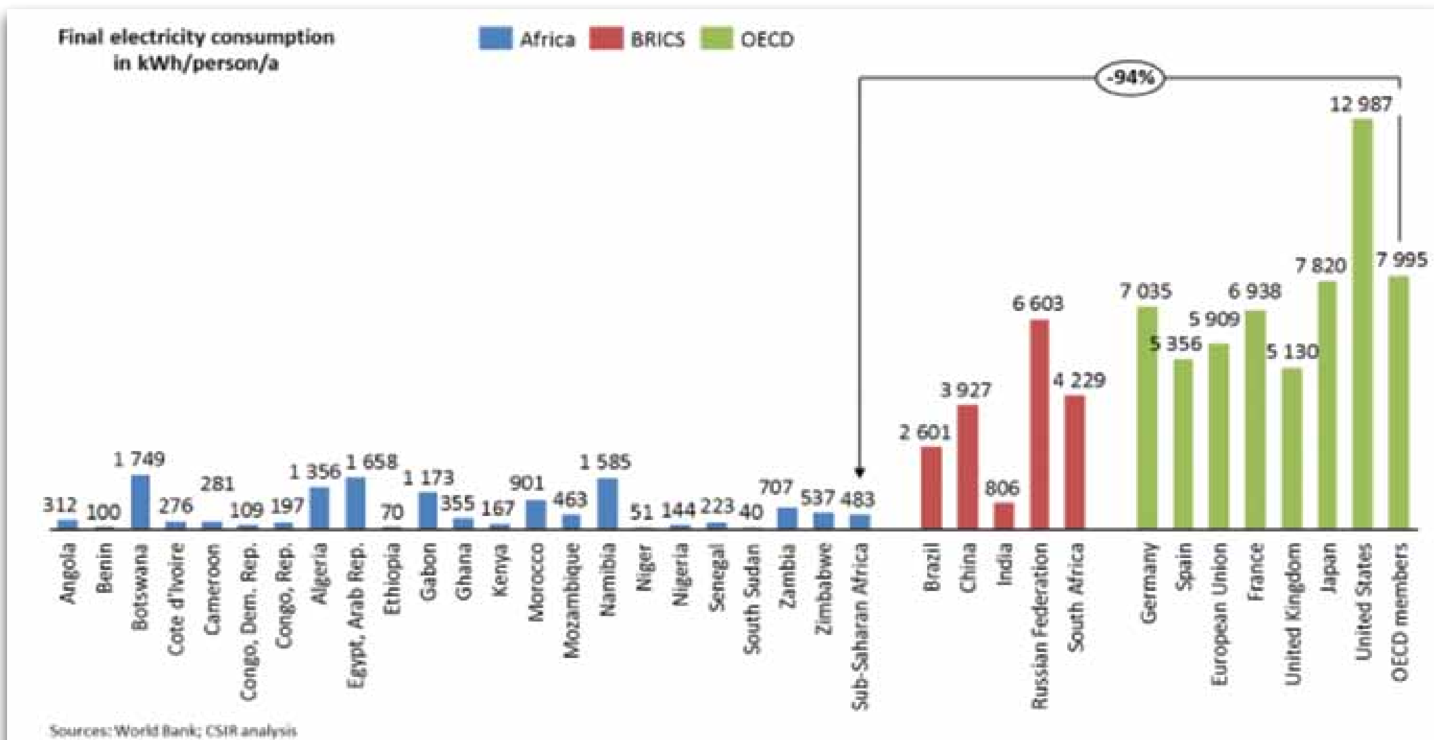

Figure 2: Electricity consumption for selected African and OECD countries, plus BRICS [2].

THE OPPORTUNITY IN SUB-SAHARAN AFRICA

Sub-Saharan Africa consumes 94% less electricity per capita than The Organisation for Economic Co-operation and Development (OECD) countries [4]. The annual energy consumption values summarised in Figure 2 illustrate the substantial potential/need for growth in energy consumption on the African continent.

Customer demand is generally distributed across wide geographic areas. Historically, this demand was supplied by large, central power generators with a high-voltage transmission backbone and medium and low voltage distribution grids, as illustrated in Figure 3.

In the future, because of cost-competitiveness of distributed renewables, the system architecture is expected to include microgrids [2, 3], potentially grid interconnected as illustrated in Figure 4.

There is a substantial opportunity for Africa to leapfrog large-scale, central power system architecture directly towards a distributed, renewables-based system as summarised in Figure 5. In such systems it is anticipated that microgrids will autonomously supply local customers, and that interconnection of the microgrids will improve reliability and reduce total cost.

CSIR PRETORIA CAMPUS

The CSIR campus in Pretoria South Africa consists of 52 buildings, spread over 170 hectare, and has an average annual

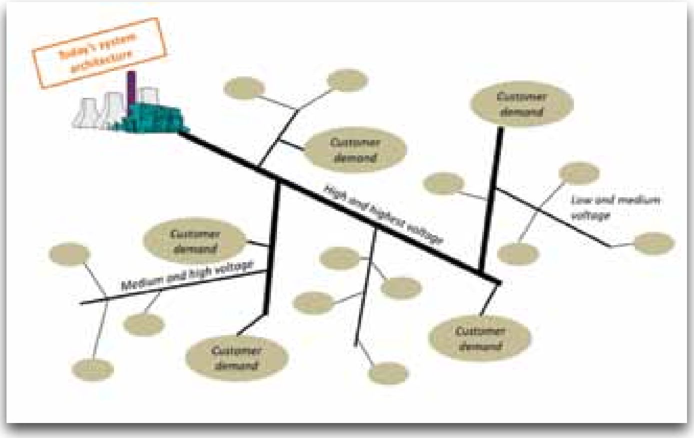

Figure 3: Present system architecture.

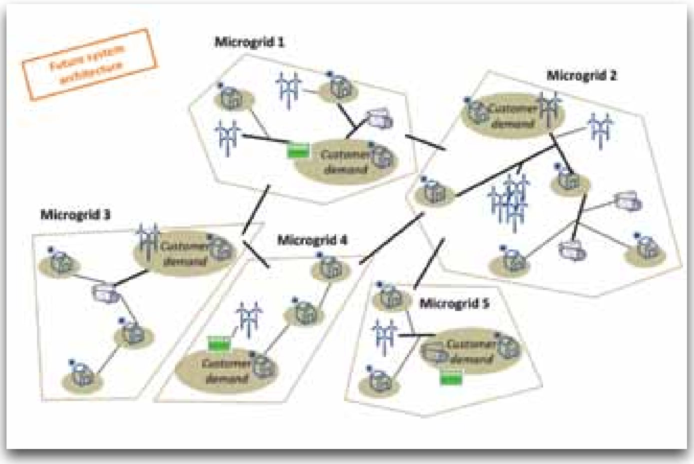

Figure 4: Future system architecture.

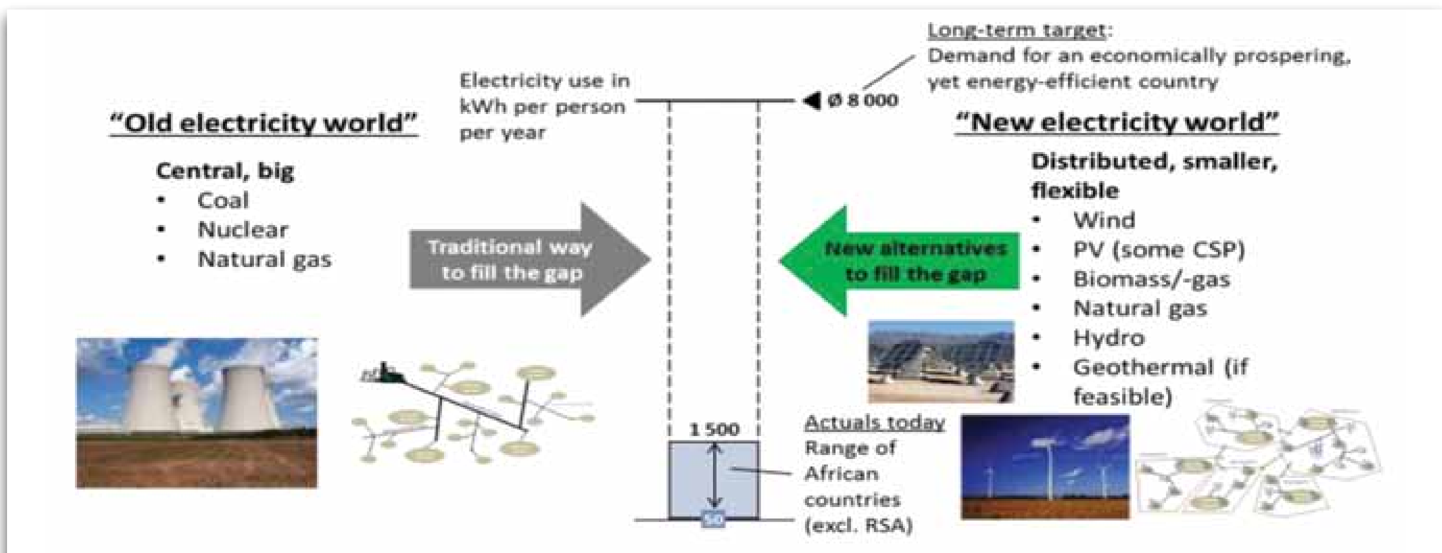

Figure 5: Summary of the anticipated energy transition

Smart Microgrids

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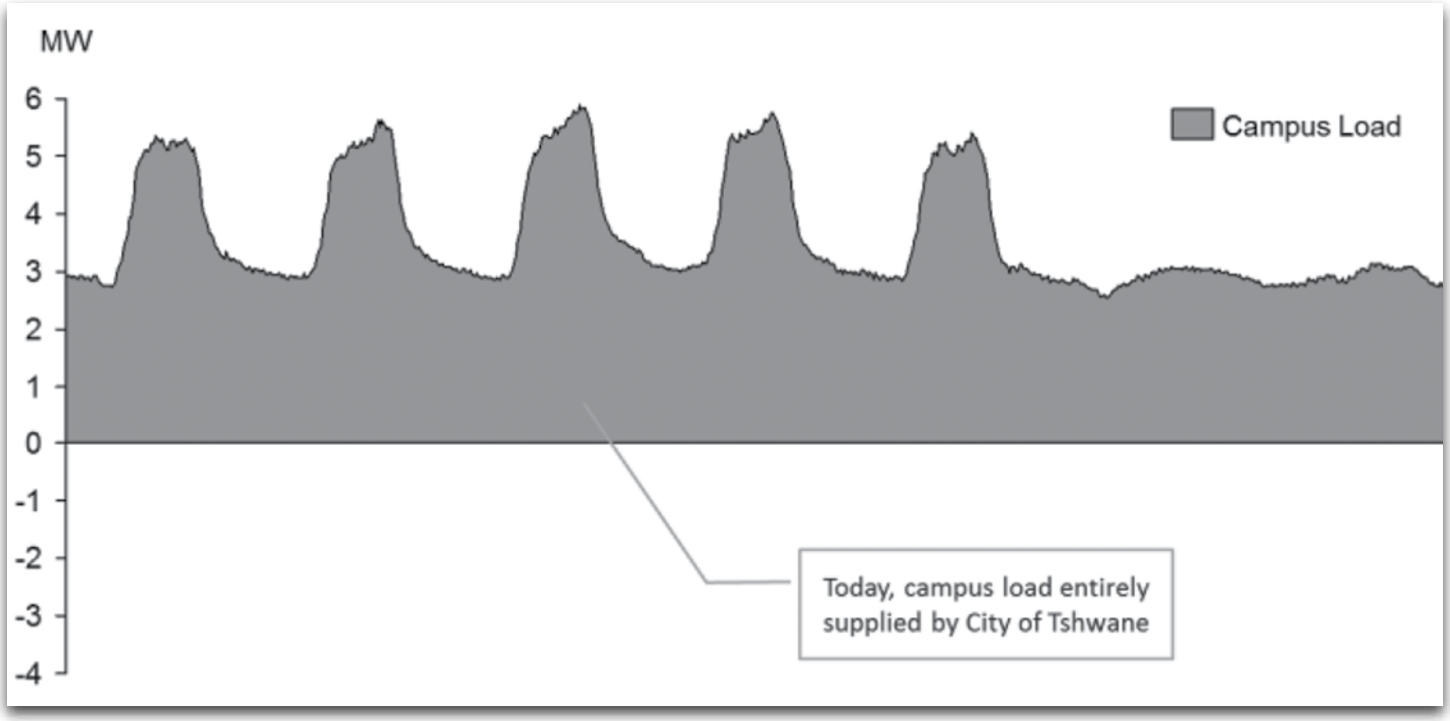

Figure 6: Present CSIR Pretoria Campus load

energy consumption of 30 GWh. The campus baseload requirement is 3 MW, and has a peak load of between 5 MW and 6 MW. A typical weekly demand profile is shown in Figure 6. The load is supplied by the local municipal electricity distributor (Tshwane Electricity) via a 132/11 kV substation. The campus 11 kV cable ring networks supply 11 kV/400 V distribution substations located in the campus buildings.

PROGRAM OBJECTIVES

The aim is to create an Energy-Autonomous Campus (EAC) by supplying energy from three primary renewable energy sources: solar, wind and biogas from biogenic waste. The power generation will be combined with demand-side management, energy-efficiency improvements and electricity and heat storage including the integration of electric and hydrogen-driven vehicles, power-to-liquid and power-to-gas processes. The other CSIR campuses across the country will gradually become part of the program, where in the long-term supply and demand will virtually be balanced across all CSIR campuses, which will form a virtual power plant.

This project will stand as a real-world research platform for designing and operating a primarily renewables-based energy system at the lowest possible cost. This platform will be used to demonstrate in a real-world setting of significant size (> 10 MW total installed capacity) how a future energy system that is based on variable and dispatchable renewables can be designed and operated in the most cost-efficient manner.

The research platform will attempt to address specific questions relating to grid-integration, optimal energy mix, energy tariff regimes, possible trading of energy between CSIR campuses and other potential customers who require green energy (using wheeling arrangements). The project will also address the demand-side component of the energy equation by identifying, developing and implementing energy-efficiency and load management initiatives.

It will also at the same time allow technology demonstrators and technology development in different renewable energy and associated technologies, different control/management philosophies, the functioning of a smart grid and its impact on the main electrical network.

The key questions being addressed include:

- What is the optimal energy mix and how can it be best/cost-efficiently implemented?

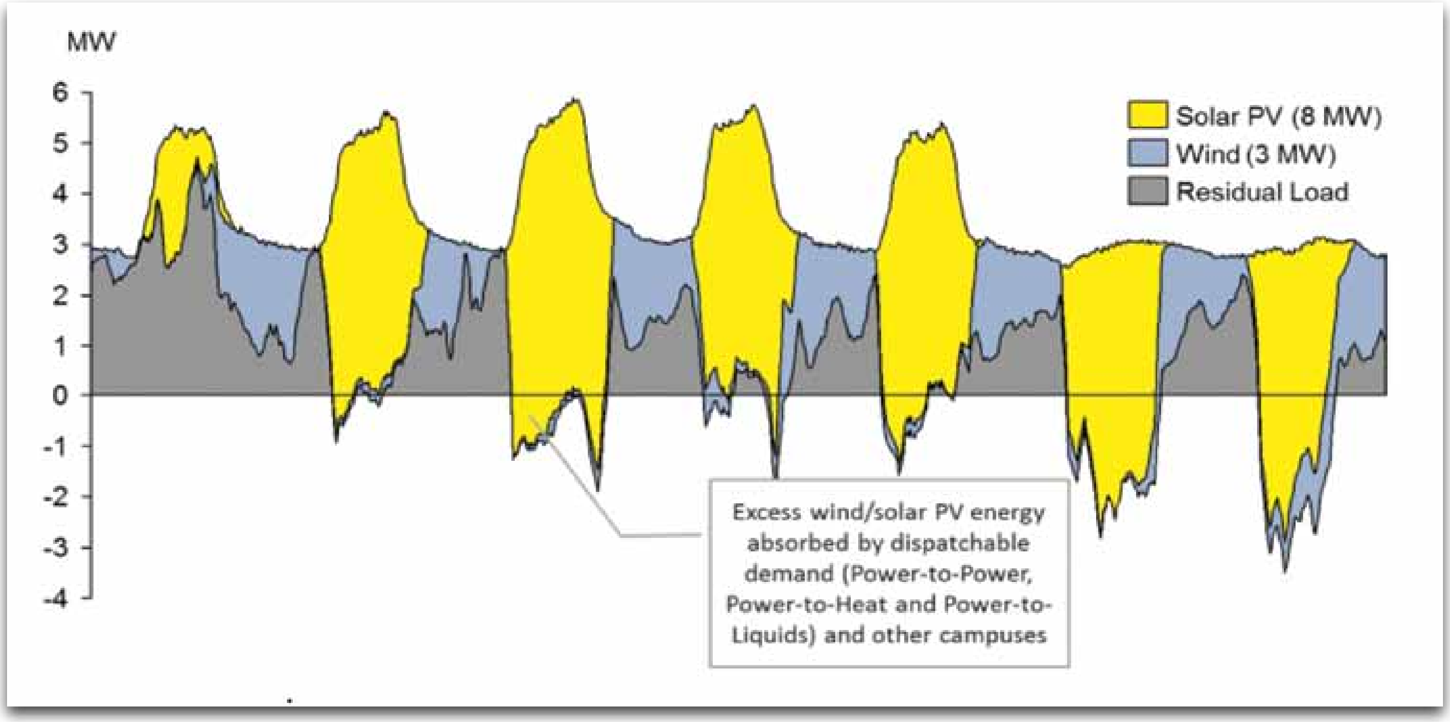

Figure 7: Illustration of campus energy supply with a combination of renewable energy sources.

- What role does the demand-side play in the design and operations?
- What storage technologies are required and how to best integrate them into the system?
- What is the optimal design and what protocols/standards are required for a campus microgrid?
- How best to operate a microgrid and combination of microgrids (containing many supply and demand resources) as a virtual power plant?

PROGRAM SCOPE

The major scope elements are as follows:

- Install approximately 8 MW of PV on all rooftops of the CSIR buildings at the Pretoria campus and another few 100 kW on rooftops at other CSIR sites across South Africa;
- Install approximately 3 MW of wind turbine(s) on the CSIR Pretoria Campus;
- Install approximately 5 MW of biogas-fired gas engines, where biogas is produced through anaerobic digestion from municipal waste. The biogas will be stored on site for the gas engines to be able to provide the flexibility that is required to balance wind/PV supply;
- Conduct an energy efficiency audit across all CSIR facilities (current demand: 30 GWh of electricity per year) and implement energy efficiency measures;
- Identify dispatchable / non-essential loads that can be utilised as a demand-side management (proving flexibility) in system operations e.g. EVs and water heating;
- Model and simulate the entire CSIR virtual power plant across all campuses to optimise the mix of renewables and dispatch regimes;
- Identify need for energy storage in the form of batteries and heat storage and implement technologies;
- Operate the system as a commercially run virtual power plant;
- Use the operational system as platform to demonstrate technologies that are further away from commercialisation, e.g. large scale electrolysers, subsequent power-to-gas and power-to-liquids processes;
- Connect the electricity and transport sectors by integrating electric vehicles into the CSIR car fleet and by establishing a hydrogen fuel station on campus for later integration of hydrogen-driven vehicles. In the long-term, establish a fuel station with carbon-neutral, own-produced synthetic diesel and petrol to supply to conventional CSIR car fleet (CO_2 + electricity from renewables + H_2O --> carbon-neutral synthetic fuels).

Smart Microgrids

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One week's electricity demand and simulated wind/solar PV on CSIR's Pretoria campus is illustrated in Figure 7, and shows the major impact that variable renewable energy systems will have on the residual load of the campus, and the potential exporting of power into the local municipal network, or the potential to store excess wind/solar energy.

PROGRESS TO DATE

Progress on the implementation of the scope is summarized as follows:

- A first phase electricity system model has been created for the Pretoria campus in Plexos®. The model requires further enhancement to model additional supply and demand side options, and a range of energy autonomy boundary conditions. The model results indicate that 6 MW of PV can be installed as a no-regret least cost option on the Pretoria campus. Further modelling is required to assess the economics of wind, biogas, energy storage, energy efficiency and demand response.
- 1 MW of PV has been installed on the Pretoria campus, consisting of a 558 kW single-axis tracker, a 200 kW dual-axis tracker and 250 kW rooftop PV installation. A further 1 MW of rooftop PV is in the process of being procured, with additional rooftop PV installations to follow. Industry guidelines have been created to aid other entities in the procurement of similar PV systems [5]. The CSIR experience has been published to inform stakeholders on the outcomes and related learnings [6].
- An EIA for a potential biogas generation plant has commenced.
- Wind measurements have been performed to assess possible wind energy yields.
- An energy efficiency audit of the campus buildings and streetlights is underway.
- A small fleet of Nissan Leaf and BMW i3 Plug-in Electric Vehicles is being operated and charged on the campus.
- An electrical model of the campus grid has been created in DigSilent PowerFactory, and is undergoing further refinement.
- The asset management practices applied on the campus electrical grid are being assessed.

SMART GRID ROADMAP

The integration of the planned renewable energy, storage and demand response technologies on the CSIR Pretoria Campus will require the implementation of a Smart Grid enabled microgrid. As such a Smart Grid roadmap needs to be developed for the CSIR Pretoria Campus, incorporating a range of interdependent projects as summarised in Figure 8.

The Campus IRP (Integrated Resource Plan) will develop the optimal mix of supply and demand side solutions to meet the forecasted electricity demand, including energy storage. The Campus IRP informs the economic case and functional specifications for the technologies that are to be integrated into the Pretoria Campus, and is hence an important input into the other studies that inform the campus electrical grid upgrades.

The Campus IRP will initially focus on the electricity system modelling, but will expand into an Integrated Energy Plan (IEP) that optimizes all forms of energy on the campus, including heating (combined heat and power from potential biogas generation) and transport (electric and hydrogen powered vehicles).

The Campus Grid Studies will model the grid impact of integrating the supply and demand side technologies identified in the Campus IRP. A range of grid studies will be performed to identify constraints in connecting and integrating the Campus IRP outcomes. Alternatives to address the constraints will be modelled and assessed, as integrating with the grid refurbishment

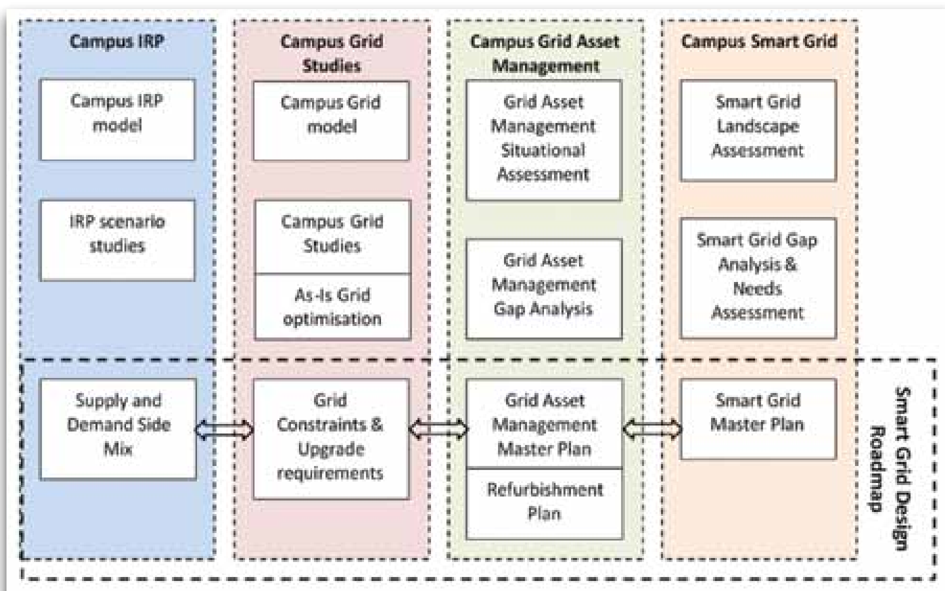

Figure 8: Projects required to develop a Smart Grid Roadmap for te CSIR Pretoria Campus.

requirements and broader Smart Grid objectives. The envisaged grid studies include; steady state load flow, fault level assessment, protection grading, grid code compliance assessment, loss minimization, reliability studies, voltage control optimization, reactive power optimization, harmonics and dynamic studies.

The studies will need to assess the implications of the relatively small spatial footprint of the campus, and the anticipated variability in renewable energy output from PV and Wind, as are anticipated to be a key integration challenge [7].

The Campus Grid Asset Management assess the alignment of the campus grid asset management with the future needs of a Smart Grid. The refurbishment needs and network risks will be identified. Furthermore the asset management assessment will cover the following key areas: asset registers, geographic and facilities management spatial information systems and data, asset care plans, asset data, single line drawings, operating procedures and contingency plans, schematics, maintenance data/history and performance data/history.

The Campus Smart Grid Project will establish the international developments and best practices in similar microgrid installations in terms of grid design, protection, visibility and control. The results of a Smart Grid Landscape Assessment will be used to perform a related gap analysis and needs assessment, the results of which will be used to develop a Campus Smart Grid Master Plan that integrates with the supply/demand mix, grid refurbishment, asset management needs and the identified grid constraints.

The outcomes of the individual projects will be integrated into a consolidated Smart Grid Design Roadmap for the campus. This roadmap will provide a phased capital upgrade plan that integrates the campus grid refurbishment, expansion, upgrade and Smart Grid requirements.

NEXT STEPS

The described projects are in varying phases of execution. Key to success will be to leverage international best practices, and develop and build relationships with other organisations, suppliers and stakeholders.

CONCLUSIONS

The implementation of a Smart grid enabled microgrid on the CSIR Pretoria campus has a number of core drivers:

- Development and establishment/ construction of renewable energy plant(s)/source(s) to supply the CSIR campus and to provide a platform for research as regards different technologies, management and control methodologies and its impact on the grid.
- The research questions range from technology choices and grid integration to changes in the regulatory framework and pricing mechanism. The work will provide critical input to the energy policy direction to be decided on by the South African Government and other countries in Africa.
- A fully functional energy-autonomous system is planned to be implemented on the campus by 2022, although some components thereof will be completed in phases prior to this milestone.
- The results will be used to develop best practice, and support the implementation of sustainable renewable energy based microgrids in the electrification of Sub-Saharan Africa.

REFERENCES

[1] J.G. Wright, T. Bischof-Niemz, J Calitz, C Mushwana, R van Heerden, M Senatla, "Formal comments on the Integrated Resource Plan (IRP) Update Assumptions, Base Case and Observations 2016" April 2017.

[2] A.G. Dagnachew, P.L. Lucas, A.F. Hof, D.E.H.J. Gernaat, H. de Boer, D.P. van Vuuren, "The role of decentralized systems in providing universal electricity access in Sub-Saharan Africa - A model-based approach", Elsevier, July 2017.

[3] G. Ireland, A. Hughes, B. Merven, "A Techno Economic Renewable Hybrid Technology Mini-Grid Simulation and Costing Model for Off-Grid Rural Electrification Planning in Sub-Saharan Africa", Domestic Use of Energy (DUE), South Africa, April 2017.

[4] World Bank energy statistics and CSIR analysis

[5] T. Bischof-Niemz, K.T. Roro, "A guideline for public entities on cost-efficient procurement of PV assets", 31st Euro PV Solar Energy Conf & Exhib EUPVSEC, Germany, p.5pp, September 2015.

[6] K.T. Roro, T. Bischof-Niemz, M.B. Ayanna, "Performance of a 558 kWp single-axis tracking solar PV system: case study in Pretoria, South Africa", 4th Southern African Solar Energy Conference (SASEC 2016), Stellenbosch, p.6pp, October 2016.

[7] T. Bischof-Niemz, C. Mushwana, S. Koopman, "Solar PV resource for higher penetration through a combined spatial aggregation with wind", EU PVSEC 2016, Munich Germany, p.1-36, June 2016.

Earn CPD Credits

Network and Data Security Strategy of the Electric Power System

This paper discusses the strategy of interconnecting the Operational Technology (OT) Environment and Information Technology Environment with a focus of cybersecurity for an electric power utility. This paper introduces the concept of "secure areas" and how these can be used to prevent the propagation of cybersecurity threats and allow co-existence with other networks. The concept of an overarching integrated security operating center and how it can integrate with the above mentioned environments is also addressed.

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The operational network of the Electric Power Utility (EPU) [1] is no longer in isolation from the rest of the organizational network and the systems the support the business.

The technological move to an interconnected network is necessary. Interconnectivity promotes both business intelligence and financial gains.

The biggest concern for the operational network however, is the cybersecurity of this new interconnected network.

THE FOUR KEY ROLE PLAYERS

The EPUs are now challenged to co-exist with the four role-players, namely:

A. **OPERATIONAL TECHNOLOGY (OT)**
The network which control, monitor and operate the power grid;

B. **INFORMATION TECHNLOGY (IT)**
The network which describes the entire spectrum of technologies used for enterprise information;

C. **INTEGRATED SECURITY OPERATIONS CENTREN (ISOC)** [2]
The network which provides security for the entire business.

D. **INTERNAL EPU TELECOMMUNICATIONS**
The internal Wide Area Network (WAN) for the EPU.

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CO-EXISTANCE

Co-existing is a challenge as OT has priorities that are in order of Availability, Integrity and Confidentiality where IT and Security has the reverse in order of Confidentiality, Integrity and Availability [3].

OT therefore accepts cybersecurity as a lower priority to the availability of the system and interconnecting current systems in their current state is a dangerous risk. The requirement on availability required by OT can encourage an EPU to host their own internal WAN.

The internal EPU WAN is seen as a highly available but untrusted network for the EPU internal OT customers such as generation, transmission and distribution sites. The internal EPU WAN can extend telecommunications to the business as a whole.

Therefore, OT, IT and ISOC can be seen as customers. If OT was to use an IT hosted system for OT operations, there would be an expectation of high availability. However, IT's top priority is Confidentiality and this will affect the expected availability for OT operations.

SECURE AREAS

A Secure Area [4] is a term used to secure a service both on site and in transport. Secure areas are setup in a manner that prevents propagation of a threat from one secure area to the next. It is important to plan for when a security compromise occurs as prevention alone is no longer sufficient. Secure areas encourage utilities to identify where services belong in their network and that they are correctly segregated.

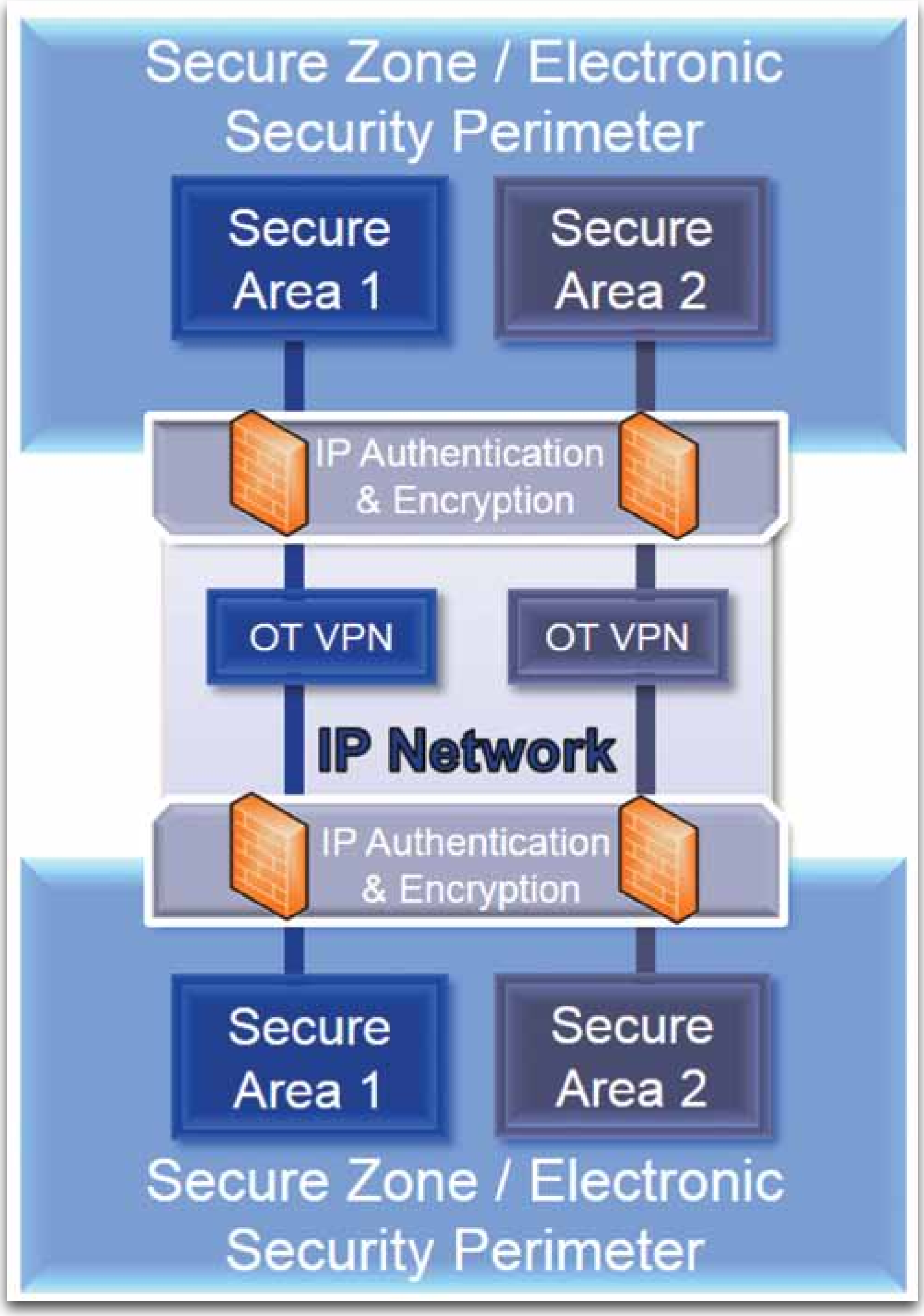

Figure 1: Example secure areas with regards to Secure Zones and Electron Security Perimeters.

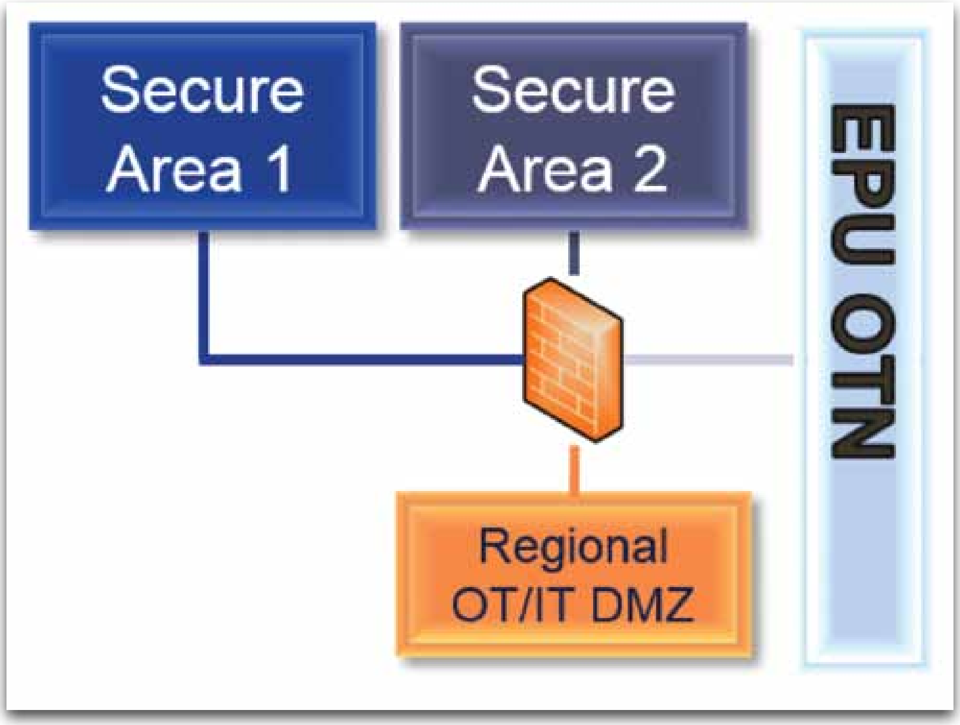

Figure 2: Logical Connection of the OT Secure Areas

Segregation of secure areas can be accomplished in the following ways [4]:

A. PHYSICAL INSULATION
There is no physical access; access is granted only on request. The industry is moving away from this method, but still viable for most critical cyber assets [5].

B. PROTOCOL INSULATION
A different protocol is used to prevent communication from leaving the network until a converter is applied.

C. FIREWALL INSULATION
Creating a barrier with rule sets to control flow of communications between secure areas.

Traditional zoning such as an electronic security perimeter [5] or secure zone [6], stop protecting once the data leaves the home network. This leaves the data to flow over an "untrusted network", regardless if that telecommunications network is internal to the business.

The purpose of the secure area is to extend the security over the telecommunications portion required by the service. Therefore, the security of the data life cycle is maintained throughout the secure area.

If an internal EPU network is used as the telecommunications, the term "untrusted network" could be removed as now the telecommunications is provided to meet the attributes of the secure area. A summary is shown in figure 1.

NETWORK & DATA SECURITY STRATEGY

A strategy is therefore required on how ISOC, IT, Internal EPU Telecommunications and OT will co-exist taking cybersecurity into the design.

Figure 3 shows the combined view of an interconnected EPU network strategy. The network has multiple secure areas [4] that separate the data on the network based on their attributes to the business.

The OT area is recommended to be divided into two secure areas, namely:

A. SECURE AREA 1 – CRITICAL OT SERVICES
Secure Area 1 is dedicated to services that directly impact the control, monitoring and operations of the power system in a critical and/or real time manner.

B. SECURE AREA 2 – NON-CRITICAL OT SERVICES
Secure Area 2 is dedicated to services that support the OT environment. A loss of this service will not crucially result in the control, monitor or operation of the power grid.

Connection leaving a secure area will go to a demilitarized zone (DMZ) and separating internally to OT reduces the risks of propagation through the OT site.

All data entering or leaving the OT environment should do so via a centralized or regionally centralized DMZ. Any data going to Secure Area 1 does not go through Secure Area 2 first. All secure areas are separate. This is shown in Figure 2.

Having data flow through a central point makes it easier to control data in an environment. This is because only one central point requires the extensive perimeter security, both hardware and human resources, for that environment.

The IT Environment can be split into 2 secure areas, namely:

Data Security

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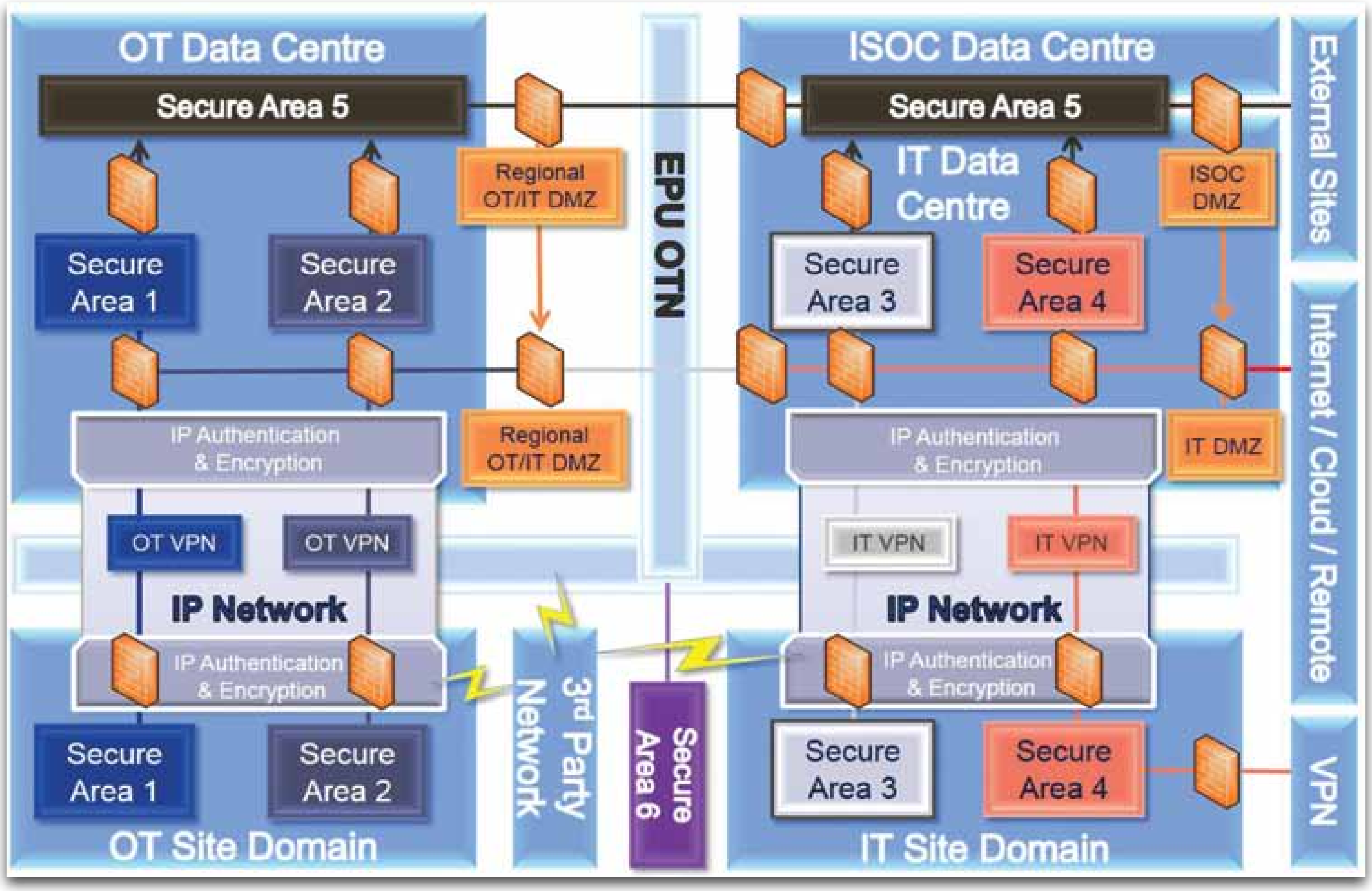

Figure 3: The Data Security Strategy of the Electric Power System.

C. SECURE AREA 3 – OPERATIONAL ENTERPRISE SERVICES

Dedicated for services hosted by IT for OT operations. The reliance for OT on IT makes this a requirement that OT hosted services on IT systems be segregated from the rest of the IT enterprise network. An agreed upon IT/OT governance will be required for services residing in this secure area.

D. SECURE AREA 3 – ENTERPRISE SERVICES

Dedicated to enterprise services maintained by IT that have no impact to OT operations. Enterprise services will follow IT governance.

Figure 4 shows the logical connection of the IT secure area. Any external connection must first pass through the IT DMZ before heading to its designated secure area, similar to the OT secure areas.

Similar to the OT secure areas, the IT secure areas will be segregated in transmission between sites. IT can use the existing internal EPU OTN to connect sites with logical separation. IT sites can use site-to-site Virtual Private Networks (VPN) services to assist with bandwidth management internal to the business.

Breaking out of the utility should be done at a single logical point. Internet, cloud, remote access, and other such external connections should pass through IT's security systems before progressing to the correct secure area. In this situation, IT security is assisting the rest of the business in security as part of a defense-in-depth [7] approach.

The Secure Areas 1 and 2 and Secure Areas 3 and 4 focus on OT and IT respectively in protecting services in those environments. There is however, a lack of visibility of the overall cybersecurity of the business.

Therefore, there is a requirement to have an area that monitors cybersecurity globally for the business. "Security" has been made

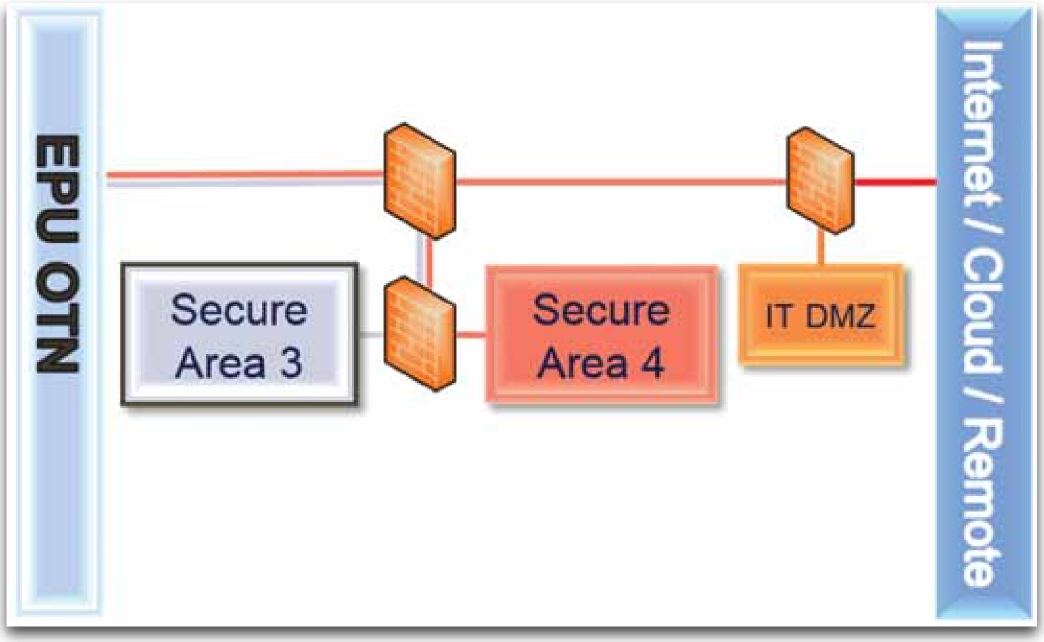

Figure 4: Logical Connection of the IT Secure Areas.

into a separate entity, similar to IT and OT, to establish the concept. It is possible that Security can be absorbed into either the IT or the OT environment, depending on the existing organization, or be a separate division.

E. SECURE AREA 5 – SECURITY

Secure Area 5 is dedicated to services controlled by ISOC. In this setup, certain cybersecurity services are provided to the whole organization.

Secure Area 5 will reside in both IT and OT environments. Security incidents will be fed from Secure Area 1-4 to Secure Area 5 directly. This information will have a high data classification sensitivity rating. Declassified information from Secure Area 5 will be shared back to the secure areas via their respective DMZ. This declassified information can be used to update system owners on how the threat occurred and what preventative measures can be implemented.

Security Area 5 also could have communication to external sites. These sites are used in the collaboration of combating cyber threats which include but not limited to:

- Agreed upon commitments with Cyber Response Committees;
- Government organizations;
- Agreed upon commitments with Cyber Response Committees; and
- Government organizations.

F. SECURE AREA 6 - EXTERNAL SERVICES

Secure Area 6 is dedicated for external services that traverse the shared physical transport infrastructure of the internal WAN. An electric power utility network could provide telecommunications along with power as part of the future smart grid strategy [8][9]. Similar to IT, services that reside in Secure Area 6 will share the same physical transport infrastructure but be logically separated.

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SHARE PHYSICAL TRANSPORT INFRASTRUCTURE

The secure areas are shown to traverse the internal EPU Optical Transport Network (OTN). The internal EPU WAN is comprised of a shared physical transport infrastructure with physically separate Internet Protocol (IP) Networks such as a Multiprotocol Label Switching (MPLS) network.

Where the internal EPU WAN is not available, a 3rd party network is utilized. The drawbacks of using a 3rd party network for OT services are that availability and latency for OT services are at risk and cybersecurity must be provided by OT sites.

If an internal WAN is used, it is possible that cybersecurity can be provided as a service to OT sites. This is an advantage as many OT sites in utilities have legacy equipment that most likely will not support current cybersecurity requirements.

At a minimum it should provide logical separation of the services in their respective secure areas. For an internal WAN, it is plausible for services to share the same physical transport infrastructure and be separated logically while maintaining a low cybersecurity risk. The 3rd party network is available for connections which is not available by the internal WAN. It can either break in at the central De-Militarised Zone (DMZ) or be treated as a remote access connection.

Utilities in the transmission environment can lay their own fibre via methods such as overhead optical ground wire. This usually becomes part of the internal EPU OTN mentioned in the above strategy. These lines are laid with ample bandwidth to sustain the growing bandwidth requirements of technologies expected in the utility environment [10].

This initial excess bandwidth on an internal EPU OTN could be serviced to external 3rd parties as a return on capital expense.

CONCLUSION

The strategy when applied together, culminates into a defense-in-depth approach. As data moves to a higher secure area, there must be permissions that allow the data to traverse further in the network.

The strategy also give motivation for hosting and maintaining an internal WAN and highlighting the possibility of a shared OTN and gives confidence in the reliance of OT to use IT host services by means of Secure Area 3.

In the event that a breach occurs, only the affected secure area will be vulnerable and the cybersecurity threat should be contained in the secure area. For example, if the corporate network residing in Secure Area 4 was breach.

The IT hosted OT services will not be impacted due to the secure area preventing the breach from propagating. The added addition of an overarching security division to monitor threats throughout the business is a step in countering the cybersecurity threats of tomorrow for the power grid.

REFERENCES

[1] Ericsson, G. N. (2007). Toward a Framework for Managing Information Security for an Electric Power Utility - CIGRE Experiences. IEEE Transactions on Power Delivery, Vol 22, No. 3, 1-9.

[2] Electric Power Research Institute. (2013). Guidelines for Planning an Integrated Security Operations Center. California.

[3] W. A. (2016). IT vs OT Security: A Time to Consider a Change in CIA to Include Resilience. 49th Hawaii International Conference on System Sciences. Hawaii.

[4] B. W. S. Z. Yongli Zhu, "The Analysis and Design of Network and Information Security of Electric Power Systems," in 2005 IEEE/PES Transmission and Distribution Conference & Exhibition, Asia and Pacific Dalian, China, 2005.

[5] North American Electric Reliability Corporation critical infrastructure protection, "CIP-005-3 Cyber Security – Electronic Security Perimeter", 2013.

[6] SABS Standards Division, SANS 62443-2-1:2016 "Part 2-1: Establishing an Industrial Automation and Control System Security Program", Pretoria, June 2016.

[7] SANS Institute InfoSec Reading Room, "Defense In Depth", 200. [Online]. Available: https://www.sans.org/reading-room/whitepapers/basics/defense-in-depth-525 [Accessed 22 August 2017].

[8] J. Van Ooteghem, B. Lannoo, S. Verbrugge, D. Colle, M. Pickavet, P. Demeester, "Can a Synergetic Cooperation Between Telecom and Utility Network Providers Lead to a Faster Rollout of Fibre to the Home Networks?," in IEEE, Belgium, 2011.

[9] L. Jianming, Z. Bingzhen, Z. Zichao, "The Smart Grid Multi-Utility Services Platform Based on Power Fiber to the Home," in IEEE, China, 2011.

[10] Akamai, "Akamai's State of the Internet," 2016. [Online]. Available: https://www.akamai.com/us/en/multimedia/documents/state-of-the- internet/q4-2016-state-of-the-internet-connectivity-report.pdf. [Accessed 27 April 2017]. wn

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- Zone 1, 2, 21, 22
- 20W, 30W, 40W
- Luminous Efficacy 120lm/W
- Ambient Working Temperature -40˚C to +55˚C
- Various Mounting Options
- 180˚ Beam Angle
- IP66

HA1 - LED Ex d Pendant Luminaire

LED

- Zone 2, 22
- 35W (2ft), 75W (4ft)
- Luminous Efficacy between 133lm/W to 136lm/W
- Ambient Working Temperature -40˚C to +55˚C
- Available With Emergency Back-Up
- IP66

HL1 - LED Ex n Linear Luminaire

LED

- Zone 1, 2, 21, 22
- Available from 30W to 240W
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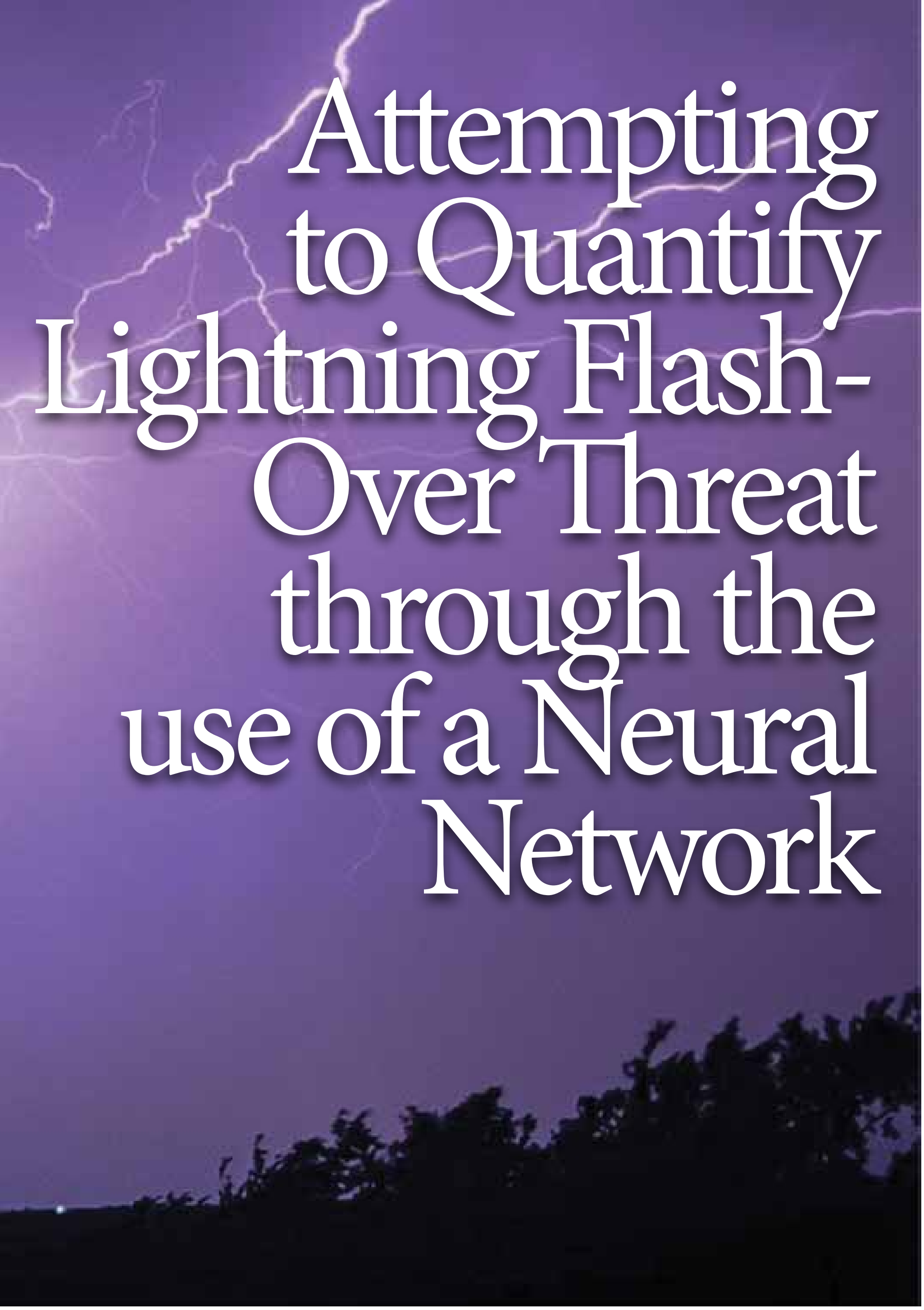
BY | OSWALD VAN GINKEL & RENIER VAN ROOYEN
ESKOM RESEARCH TESTING AND DEVELOPMENT

In this paper, the possibilities provided by a neural network as a modelling technique to determine the threat lightning storm clusters pose to a high voltage transmission line is investigated. Some background information is provided, to support the use of a neural network in this particular context, and the methodology used is discussed prior to providing results.

Attempting to Quantify Lightning Flash-Over Threat through the use of a Neural Network



Lightning is a natural occurrence that has several detrimental effects on an electrical power grid's operation, and its maintenance. Due to the erratic nature of the phenomena, it becomes necessary for a System Operator to be able to anticipate the movement and quantify the danger that any particular lightning storm presents at any given moment.

A flash-over, as a result of lightning discharge, is very difficult to define, as the event in question involves complex electromagnetics, impedances in the area and gas discharge physics. The nature of the phenomena demands research into new ways of modelling its behaviour.

An artificial neural network is a modelling approach that is known to allow fitting highly non-linear classification or regression problems [1]. Being able to handle noise [2] it could possibly serve as an excellent choice to map lightning characteristics and line design parameters to actual outages. But it is highlighted by various sources that especially the back propagation algorithm requires enough training data to efficiently reach a good generalizable state.

Lightning Flash over

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As indicated in [1] it is necessary to standardise the input variables in some way. This process may involve normalisation as well as some of the feature discovery approaches proposed by [3]. In the case of lightning storms, clusters have a derived probability of having a number of strikes above 80 kA. This is substantiated by the design methodology stipulated in [4]. This could possibly serve as an additional feature to simplify the solution search space and obtain a more generalizable trained model as was the case with the examples [5] demonstrated.

[3] uses a methodology that uses equal amounts of data where the output needed to indicate an outage or a non-outage greatly enhanced the training result. This ensured a low number of training epochs in order to reach a stable error (typically less than 200 epochs). This enhanced learning capacity after pre-processing the input data agrees with the findings of [3]. In this instance a different form of pre-processing was implemented to prevent biased training (higher probability to output a certain value due to more occurrences in input data).

Since there is no definite known relationship and a great influence of probability in whether a lightning induced outage will occur as a result of a lightning discharge within a storm with certain characteristics [1] supports a neural network as a good approach to modelling this complex relationship. [1] states that a neural network can be construed without prior assumptions on the "functional form of the relationship between predictors and response".

Other interesting and relevant uses of neural networks include the supervised

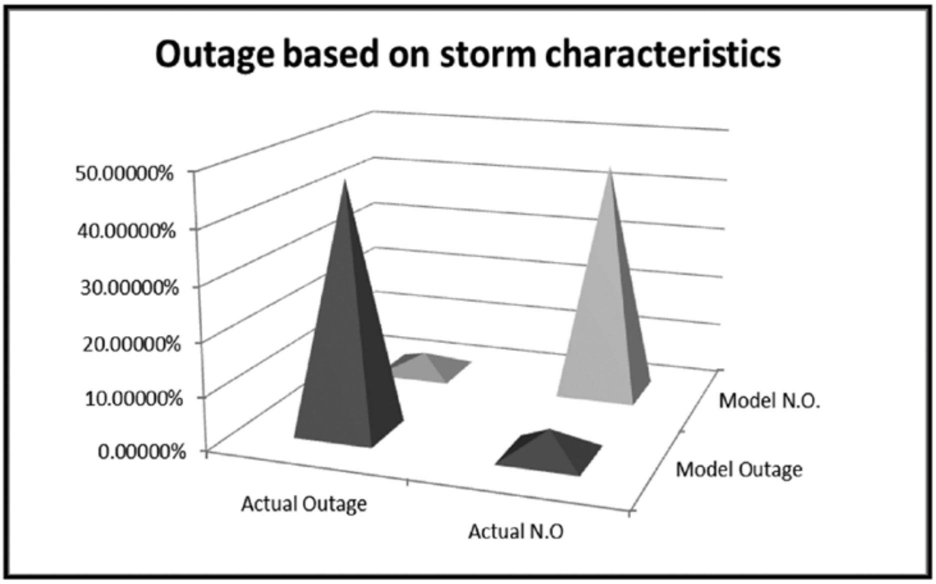

Figure 1: Confusion matrix of predicted vs actual outages without tower design threshold.

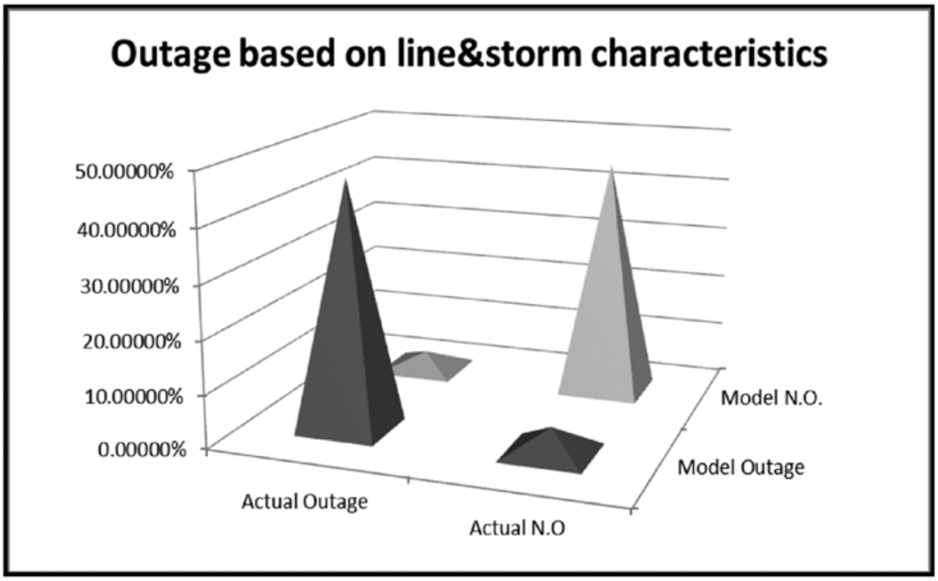

Figure 2: Confusion matrix of predicted vs actual outages with tower design threshold.

classification of plant communities [5] and the use of a neural network for real-time process control in a water treatment system [6].

METHODOLOGY

The investigation will consider the following input data:

- A list of outages (time and location);
- Clustered lightning storms indicated to coincide with lines due to occurring in the same columns as the lines (STORM);
- Pre-calculated minimum current required to pose a threat to a transmission line based on available design data (LINE).

It should be noted that at the compilation of this research effort only 1 year's worth of lightning data was used. The model will be tested against its own training data to see if a relationship with the input parameters can be established.

The Methodology is outlined as the following:

Existing logs (Incident Report) from within the Eskom System Operator Data Warehouse is utilised to extract a list of outages or faults for the period under evaluation. Data fields utilized from the Incident Reports include:

- "Start time"; and
- "First Equipment".

Start time is processed by rounding it to the nearest 10 minute interval. This coincides with a chosen storm cluster interval of 10 minutes chosen for its ability to form sensible and relatable clusters.

From the highly detailed lightning feed supplied from the South African Weather Services, lightning clusters are formed and for each cluster the relevant storm characteristics are compiled.

For the experiment these characteristics include:

- A 10-minute time interval field.
- The total number of discharges in the storm
- A list of 10 kA current bins.

Lightning Flash over

continues from page 45

After processing outages that correlate with lightning data two sets of data emerge: storm outages and non-storm outages.

To be able to efficiently train a model, that should link storm characteristics to an outage, and ensure that biasing doesn't occur to either outages or non-outages it is necessary to expose the model to approximately equal amounts of outage and non-outage cases.

Non-storm related outages greatly outnumber storm related outages by the order of 110:1 (for 11000 storm clusters over lines during a year timespan). An equal balance between outage and non-outage numbers in samples is ensured by duplicating actual storm outages in the training data.

The results from training an artificial neural network based classifier model based on FANN [7] led to the following results:
In the figure provided, it can be seen that the trained model was able to correctly classify most of the storms that would cause outages based on the storm characteristics included in the training of the model. Accurate predictions based on non- outage instances were also mostly correctly predicted. In total the models accuracy can be aggregated to 91.7%.

An additional input to the classifier was evaluated namely the pre-calculated design current for specific towers based on the dominant type of towers within a transmission line assembly. With this additional parameter, the model did not perform significantly differently from the model that did not have this design parameter added (90.8% correct classification of outages and non-outages).

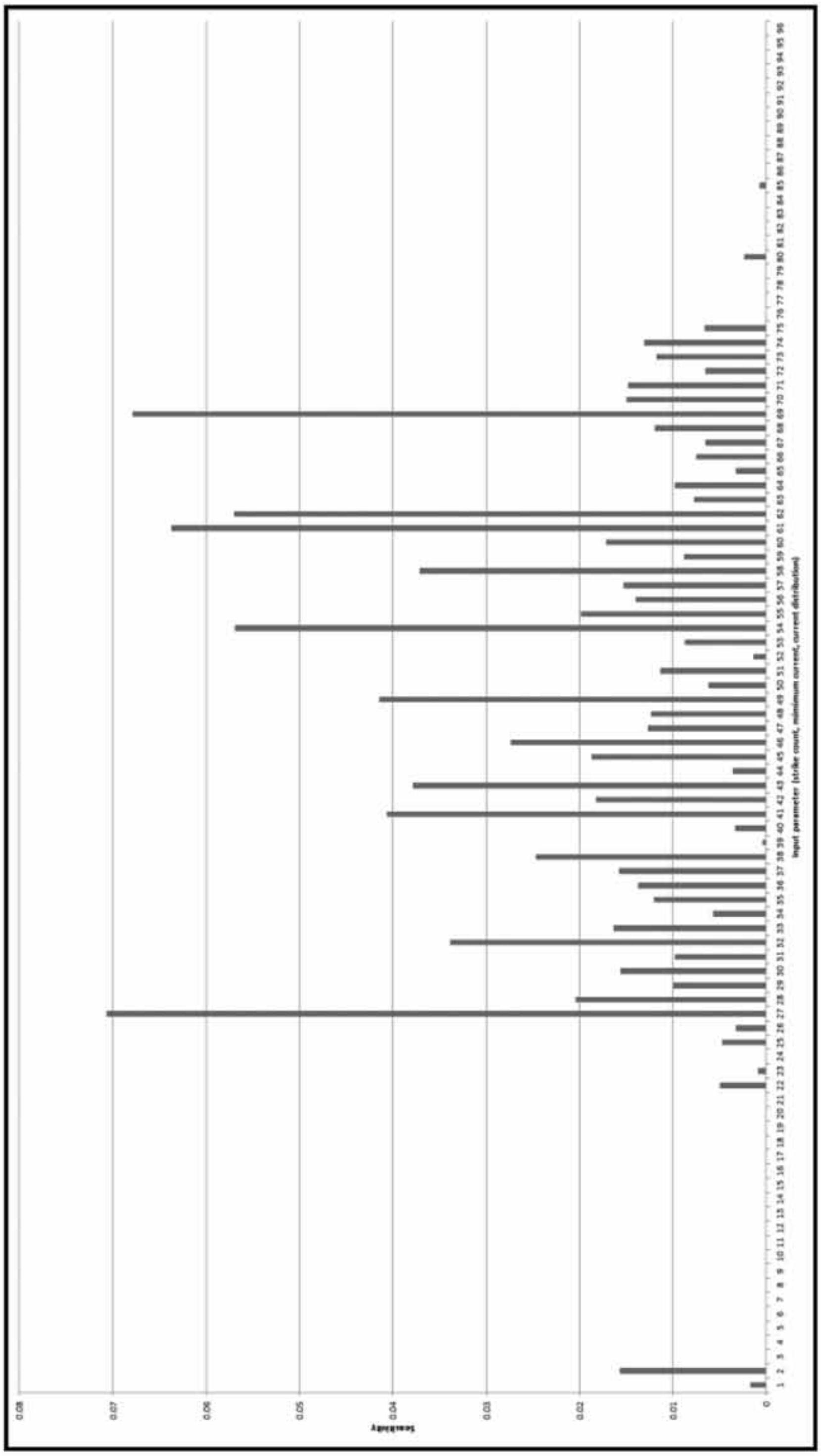

Figure 3: Neural network parameters sensitivity analysis.

To be able to ensure that such a model will effectively function in most cases as a filter for relevant alerts it would be required to train it on larger lightning data sets provided that accurate outage and fault records are available.

Figure 3 represents the sensitivity analysis conducted on the training parameters used in the neural network. From the figure the impact of both the design values of the lines and the lower current and higher current strokes can be seen as separated into each bin. The first two parameters correspond with stroke count and design values respectively. The other parameters indicate the kA divisions as previously noted. It should be noted for clarity sake that the results presented within the figures are as a result of testing the model on the dataset on which it was trained. The result seems to offer a promising result in terms of generalizability of a future model.

Further tests using a larger lightning dataset is required in order to make conclusive remarks on the viability of this method and modelling technique.

CONCLUSION

The research presented in the paper definitively indicates a relationship between the characteristics within a lightning storm and the outages caused as a result thereof through the results of the model that was trained using a neural network.

The results of the training base case create compelling results which demand further investigation.

The overall performance of 91.3% accuracy indicates a viable opportunity to limit alarms raised by lightning discharges' intersection with high voltage transmission lines, thus improving the overall situational awareness of a Transmission System Operator.

Further training and tests are required in order to properly deduce the applicability to the Eskom System operator and the power industry at large.

BIBLIOGRAPHY

[1] H. S. Stern, American Statistical Association and the American Society for Quality Control Technometrics, vol. 38, no. 3, 1996.

[2] D. Rumelhart, J. McClelland and P. R. Group, Parallel distributed processing: explorations the microstructure of cognition vol 1: Foundations, vol. 1, Cambridge: The MIT Press, 1986.

[3]S. Piramuthu, H. Ragavan and M. J. ShawSource, "Management Science," [Online]. Available: http://www.jstor.org/stable/2634678.

[4] J. Anderson, "Lightning Performance of Transmission Lines," in Transmission Line Reference Book - 345kV and Above, Palo Alto, California, Electric Power Research Institute, 1982, pp. 545-596.

[5] L. Černá and M. Chytrý, "Supervised classification of plant communities," [Online]. Available: http://www.jstor.org/stable/409662. [Accessed April 2014].

[6] Q. J. Zhang, R. Shariff, D. W. Smith and S. S. A. Cudrak, "Artificial neural network real-time process control system for small utilities," [Online]. Available: http://www.jstor.org/stable/41313325.

[7] S. Nissen, "Implementation of a Fast Artificial Neural Network library (FANN)," 2003. wn

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BY | MOEKETSI TSOSANE & PETER FREERE & ALAN ROBERTS
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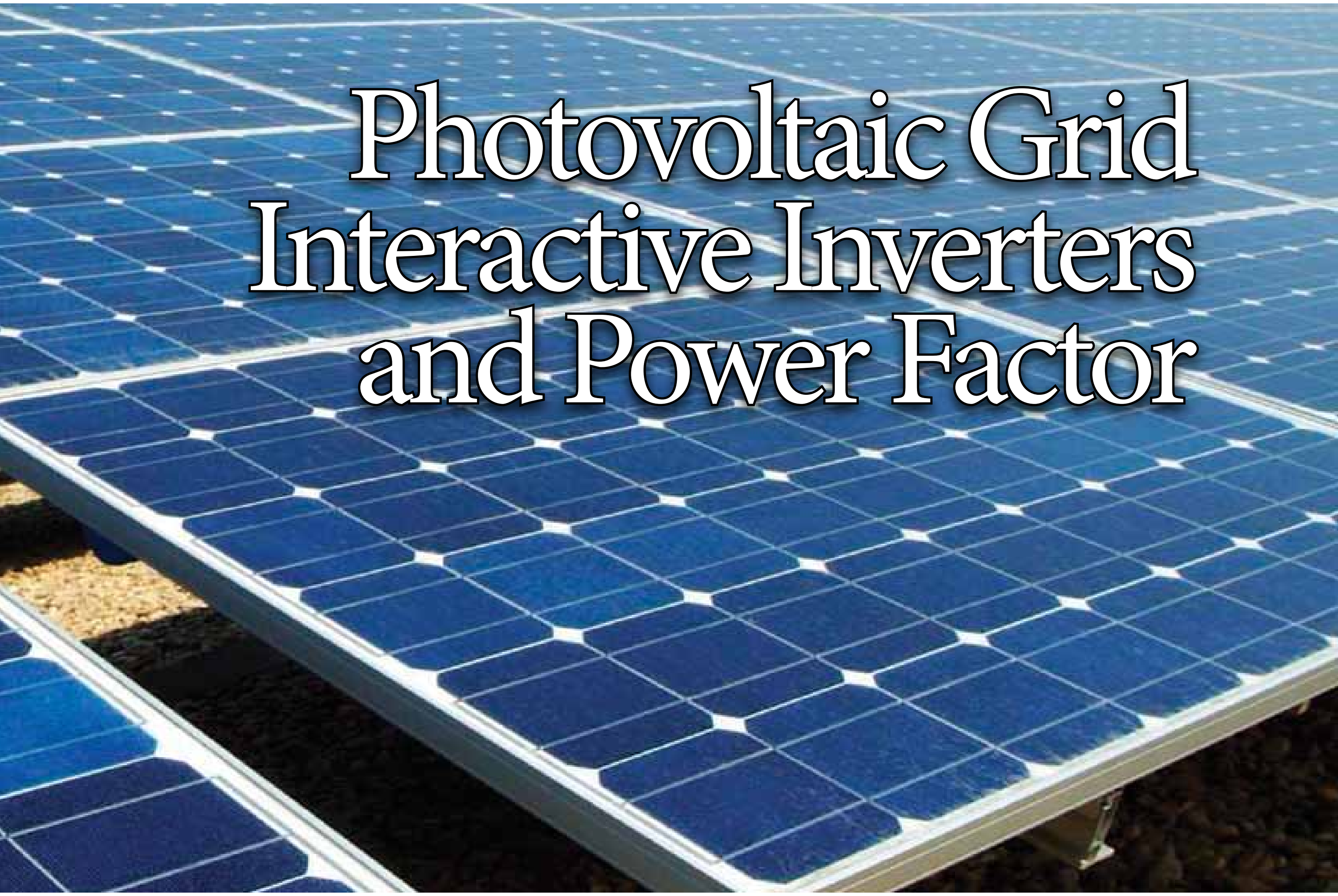
This paper focuses on the power factor and the reactive power flow from commercial photovoltaic system inverters, and the effect of power factor on the distribution system. The concept of reactive power flow from inverters rated at unity power factor is discussed and clarified as it should be considered when designing distribution system with high photovoltaic energy penetration. Challenges regarding inverters with reactive power flow capabilities are identified, and recommendations are provided regarding the reactive power flow on distributions systems with the likelihood of high future photovoltaic energy Penetration.



Photovoltaic Grid Interactive Inverters and Power Factor

There has been a focus on improving efficiency from the DC power converted from the photovoltaic solar panels to the AC power delivered to the load. According to [1], the main objective of a photovoltaic system is to convert all available energy from the photovoltaic panel's DC bus to AC kWhrs in the most efficient and effective manner. In many countries consumers are paid for kWhrs delivered to the power system grid. This means producing anything other than real power is not desirable for the photovoltaic system owner [1].

Hence, many converters utilize the maximum power point tracking (MPPT) mode of operation and unity power factor to ensure high efficiency of the conversion stage [2]. Most commercially available photovoltaic converters in South Africa are limited to unity power factor and rated in kW (real power) or kWp. With no licensing required in South Africa for photovoltaic systems less than 1MVA, photovoltaic systems are becoming more common for domestic, commercial and industrial consumers.

UNITY POWER FACTOR INVERTERS

Many inverters available for grid tied operations have functions to control the delivery of the active power available. Inverters with unity power factor rating will ensure that the inverter only delivers real power resulting in any reactive power required by the load being consumed from the grid. Figure 1 shows a typical grid connected photovoltaic system, with a load of 1000 kVA and a photovoltaic system of 500 kWp (measured by power meter photovoltaic-PM) in co-generating with the grid (measured by power meter GS-PM).

The example in Figure 1 indicates the load requirements of 1000 kVA made up of 800 kW and 600 kVAr. When the photovoltaic system is generating 200 kW, from the grid side the load will appear to be 600 kW and 600 kVAr which results in GS-PM reading a load of 848,5kVA at pf = 0,707 (Figure 1). If the photovoltaic system generates 500 kW for the same load, from the grid side the load will appear to

Photovoltaic Grid

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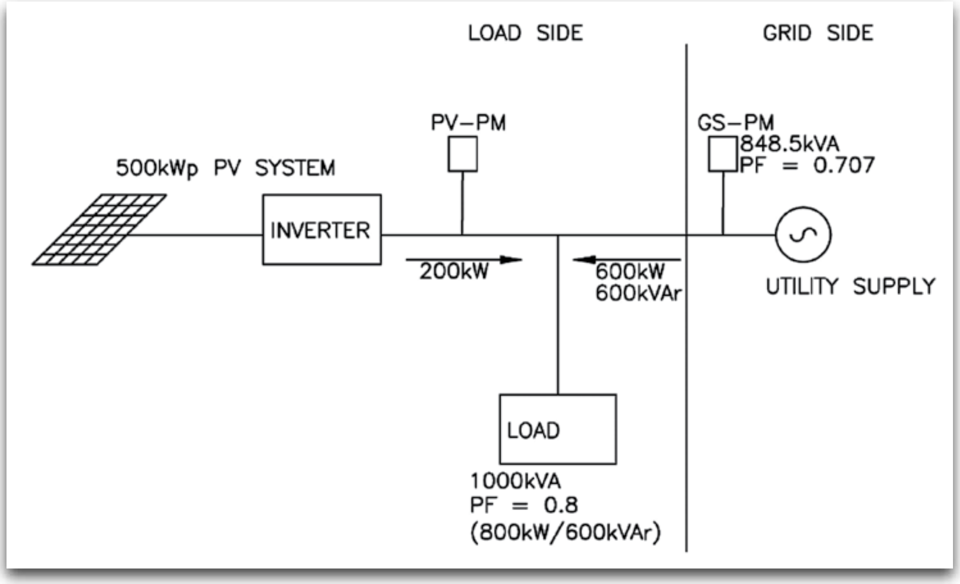

Figure 1: Active and reactie power flow for a load with unity rated power factor grid-tied photovoltaic system.

be 300 kW and 600 kVAr which results in GS-PM reading a load of 670,8 kVA at 0,45 power factor.

It can be noted that the more the real power is consumed by the load from the photovoltaic system, the lower the ration of real power to reactive power is supplied by the grid, hence the worse the power factor appears to be from the grid side. From the utility supplier, this appears to be a load with a lowering power factor.

In some countries, e.g. Malaysia, customers are penalized for low power factors [16], hence it is not desirable for a load to appear to have low power factor, even though the apparent power may be very small. Here, for voltages below 132 kV, any power factor below 0.85 in the billing period, attracts a penalty of 1.5% for every 0.01 of the power factor below 0.85.

With many of the South African tariffs penalizing the peak kVA consumed, it is noted that high penetrations of kW only, does not effectively reduce the peak kVA. An interesting scenario can arise when the load is about 470 kVA at 0,85 power factor, which will result in approximately 400 kW real power load and approximately 247 kVAr.

If the photovoltaic system generates 400 kW the grid will supply a load of 247 kVA (247 kVAr) at approximately pf = 0 read by GS-PM. For a tariff system that penalize low power factor, this can be a difficulty for the consumer. For a tariff that focuses on peak demand only, the cost would be based on 247 kVA (assuming it is the highest in the month).

Furthermore, if the load was to remain the same and the photovoltaic system delivered 500 kW, the active power flow will change at the point of common coupling.

From the grid side this will appear to be a load that is sending real power (100 kW) back to the grid but consuming reactive power of 247 kVAr.

Under a maximum kVA charge regime, the net apparent power will increase to 266 kVA which the consumer will be liable. In this case power factor will be negative (pf = 0.375) and lower.

The above scenario makes it clear that when a photovoltaic system rated at unity power factor is considered, the reactive power requirement of the load must be considered. It is a common practice for installations to have some sort of power factor correction, but with the inclusion of a photovoltaic system on an existing electrical installation, it is important to consider the power factor and kVA as viewed from the grid.

UNITY POWER FACTOR INVERTERS WITH FILTERS

According to [3] Germany's photovoltaic system contributes about 6% of the national electricity supply, with about 80% of the photovoltaic system connected to the low voltage system. Photovoltaic system inverters normally have an output filter to produce a pure sine wave and to reduce total harmonic distortions. In [3] it was discovered that inverters with a power factor specification of unity may have reactive power flow, depending on the real power delivered and the size or make of inverter. Figure 2. indicates the relationship over several days between the real and reactive power flow of one inverter, rated at unity power factor measured [3].

Due to the filter on the output of this inverter (Figure 3), the inverter filter capacitance is able to provide reactive power when the inverter is producing sufficiently low real power. It is also interesting that when the

inverter is delivering high real power, it also consumes reactive power or becomes a reactive burden to the grid. In this case reactive power flows between the grid/load and the inverter [3]. This implies that the unity power factor output of the inverter is determined between the inverter and the filter, rather than between the filter and the grid as would be expected.

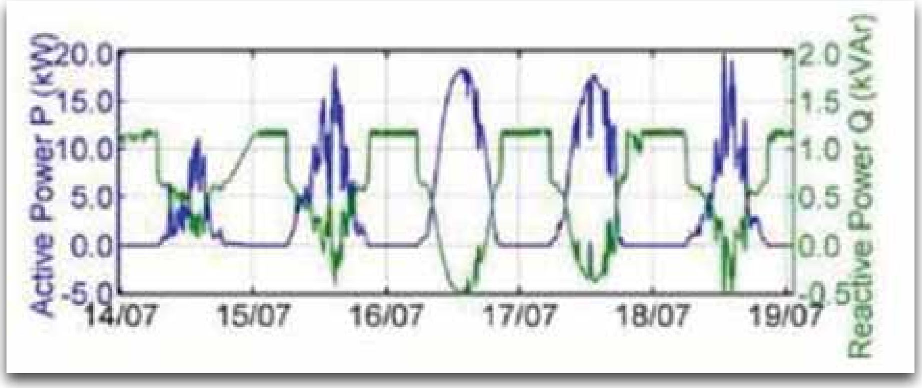

Figure 2: Real and reactive power flow measureents from a unity rated grid-tied inverter [3].

INVERTER FILTER BASIC OPERATION

The common types of filters used in pulse width modulated inverters are L, LC and LCL filters. According to [4] L only filters are common in VSI but they only attenuate high frequencies at 20 DB/decade.

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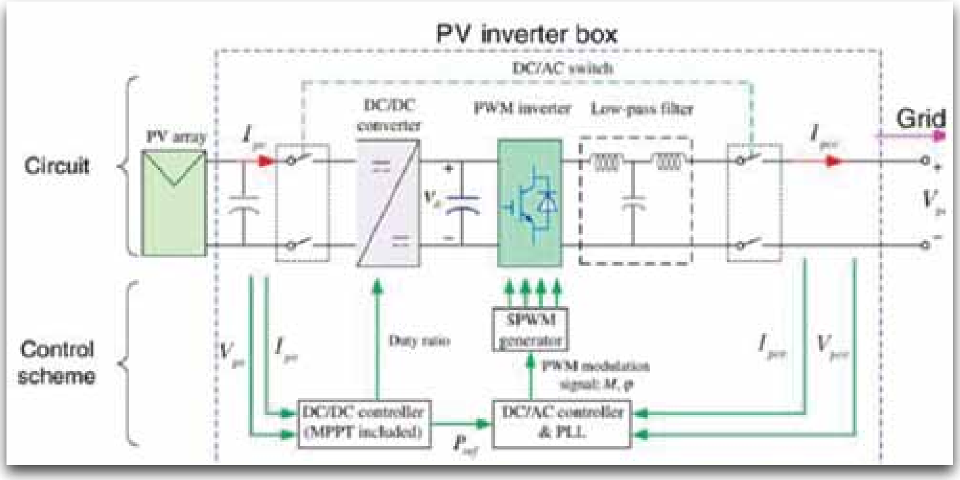

Figure 3: General components arrangemenr for a typicl grid connected inverter [6].

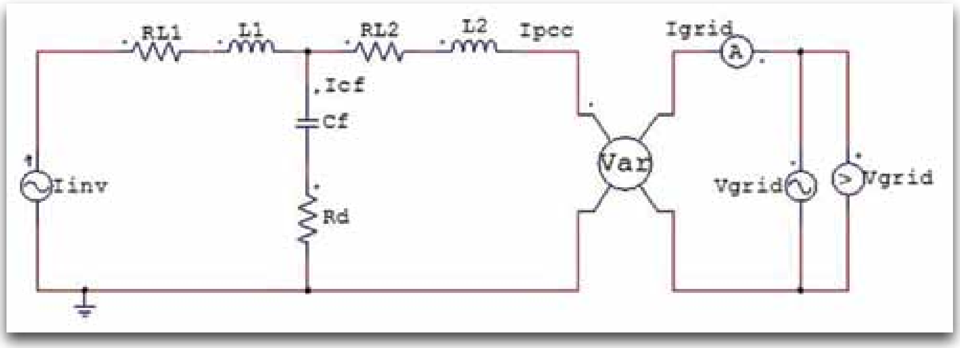

Figure 4: Equivaelnt circuit diagram for analysis of a grid tied inverter with LCL filter.

The output current of an inverter will contain high frequency components near the switching frequency, which is usually caused by the pulse width modulation switching process (at frequencies between 2 and 20 kHz). LC or LCL low pass filters are more common as compared to L filters, with the parallel capacitor providing low impedance path for high frequency current ripple, resulting in attenuation of ripple current injected in the grid [6]. The best attenuation of harmonic currents is with the LCL filter which has the advantage of reduced components sizes and can be relatively cheaper [7]. The major drawback of LCL filters is resonance problems. At certain frequencies, the impedance of an inverter with a LCL filter can resonate with the impedance of the grid, resulting in loss of attenuation of high frequency ripple currents.

The methods and ways of reducing the resonance effects are currently under research, but the common method is to provide a damping resistor R as indicated in [4], [6], [10], [11] and [15].

POWER FACTOR

Due to inductors and capacitors in the LCL filters, some reactive power flow can be expected between the inverter and the grid. When a voltage source inverter is synchronized with the grid, the voltage will remain constant and the current will be supplied from the photovoltaic system to the grid depending on solar energy available. In this condition, the inverter will behave like a controlled current source as the voltage will depend on the grid voltage. Therefore, for analysis purposes, an equivalent circuit diagram shown in Figure 4 is used to assess the impact of the inverter filter at fundamental frequency.

Applying the theorem of superposition, the following equations where derived and used to resolve the current supplied to the grid I_{PCC}, Load current I_L, grid current I_{GRID} and the current through the capacitor IC_f

$$I_{PCC} = \frac{I_{INV} \times \left[R_D - j\left(\frac{1}{(2\pi f C_f)}\right)\right] - V_{GRID}}{R_D - j\left(\frac{1}{(2\pi f C_f)}\right) + R_{L2} + j(2\pi f L_2)} \quad (1)$$

$$I_L = \frac{V_G}{Z_L} \quad (2)$$

$$I_{GRID} = I_{PCC} - I_L = \frac{I_{INV} \times \left[R_D - j\left(\frac{1}{(2\pi f C_f)}\right)\right] - V_{GRID}}{R_D - j\left(\frac{1}{(2\pi f C_f)}\right) + R_{L2} + j(2\pi f L_2)} - \frac{V_G}{Z_L} \quad (3)$$

$$I_{C1} = \frac{I_{INV} \times [R_{L2} + j(2\pi f L_2)] + V_{GRID}}{R_D - j\left(\frac{1}{(2\pi f C_f)}\right) + R_{L2} + j(2\pi f L_2)} \quad (4)$$

Where f is frequency, R_D the damping resistor and R_{L2} the internal resistance of L_2

Using the values of an LCL filter from [5], when the inverter is not producing any real power and connected to the grid directly (without a load), the current flow is indicated by the PSim simulation results in Figure 5. In this condition, the filter impedance is mainly capacitive and will provide reactive power to the grid depending on the value of C_f.

When the inverter current before the filter is zero, and so the filter impedance as seen from the grid will be capacitive $(722\angle -89.9^{\circ}\Omega)$

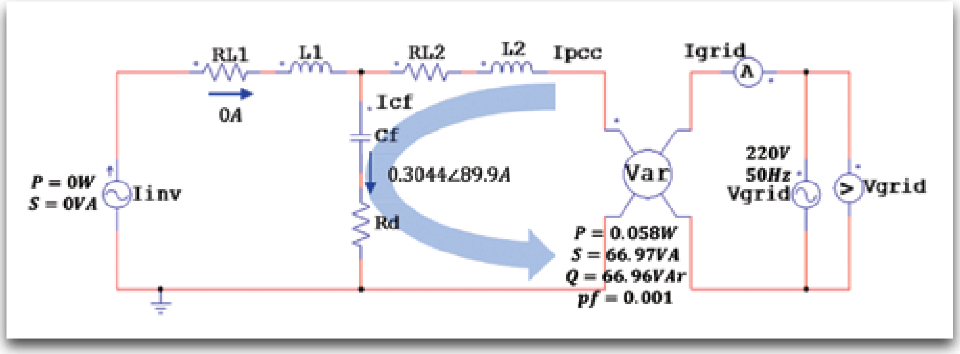

Figure 5: Calculated reactive power and currents caused by the inverter filtr when the pv system is producing zero amps.

and will provide a reactive power of 66.7 VAr to the grid. This explains it is likely that the inverter output filter of the inverter in Figure 2. produced a reactive power of 1 kVAr when the inverter is not delivering any real power.

Assuming the inverter in Figure 5 is limited to unity power factor and producing 1200 W, the current flowing from the inverter will be 5.45 A in phase with the voltage at 0^0. Figure 6, shows the calculated currents using the theorem of superposition for both sources at fundamental frequency of 50 Hz. From the currents calculated it can be noted that even if the inverter supplies current at unity power factor, the current sent to the grid is lagging the voltage by 3.2° resulting in a power factor of 0.9815. Due to the current supplied to the grid lagging the voltage by 3.2^0, the grid appears to an inductive load which implies that the inverter is supplying reactive power of 66.42 VAr to the grid. The series inductance of this filter results in low inductive reactive power at 50 Hz as compared to the reactive power produced by the filter Capacitor even at rated current.

In a practical application, the inverter current and voltage will not be exactly in phase, some of the reactive current will circulate in the inverter through the bypass diodes of inverter switches. In fact, this will be the case if the inverter is connected in an islanded mode, even if the load is purely resistive, the reactive currents produced by the filter will circulate through the inverter. The amount of the reactive current allowed to circulate through the inverter will affect the amount of reactive supplied or demanded from the grid by the inverter filter. Figure 7 indicates an operation condition where the current from the inverter is at a power factor of 0.997 p.u. At this condition, the current to the grid will lead the voltage by 0.79^0 which means the grid is supplying reactive power (appears to be a capacitive load) of 16.52 VAr back to the inverter filter.

If the reactive power produced by the filter is not allowed to circulate in the inverter circuit (due to it operating at unity power factor), all the reactive power will be supplied to or from the grid. If the filter reactive power is allowed to circulate between the filter and the inverter, the reactive power can be demanded or provided back to the grid as desired.

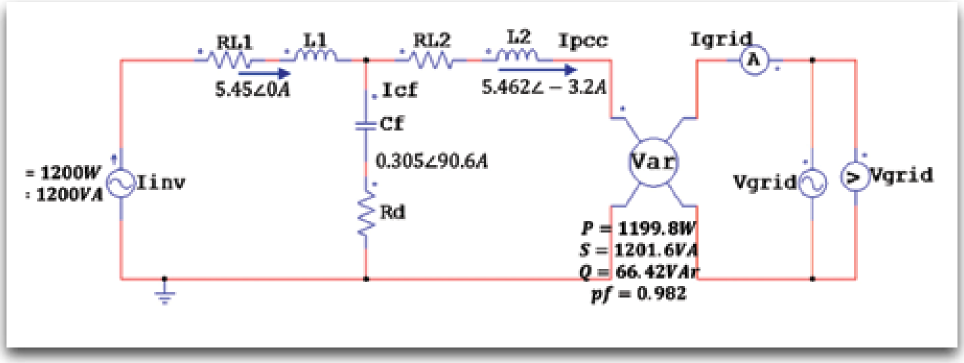

Figure 6: Calculated reactive power and currents caused by the inverter filter, when the photovoltaic system is producing 1200 W at unity power factor.

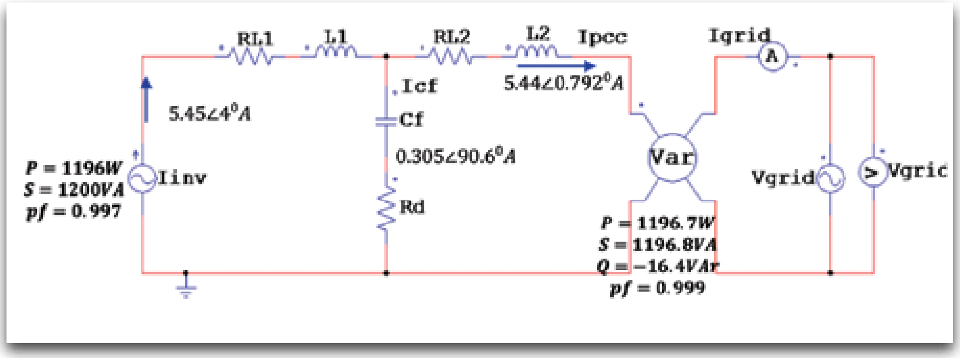

Figure 7: Calculated reactive power and currents caused by the inverter filter, when the pv system is producing 1200 VA at 0.997 p.u. power factor.

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IMPACTS OF REACTIVE POWER FLOW

Though the reactive power flow is low in magnitude compared to the rated output of the inverter, a larger scale installation of photovoltaic systems with inverters rated for unity power factor could be a cause for concern. Consider Figure 8 for a domestic application with a photovoltaic system as per Figure 5.

Domestic loads normally peak in the early morning or late evening when power available from the photovoltaic is very low or zero. During the day, most of the energy generated by the photovoltaic system will result in the current from or to the grid being very low, which mean any reactive power will not make a significant deference to the cable loading. During high consumption time at about 19h00, the peak load will be 2.5 kW, and the reactive power will be a capacitive 66 VAr (photovoltaic output is 0 W) resulting 2501 VA which is not a significant difference. A filter utilized in [8] resulted in a maximum capacitive reactive power of 206.3 VAr with a single phase 220 V, 50 Hz grid supply. This indicates that reactive power depends on the type of filter used for the inverters and this phenomenon should be monitored as it can slightly increase the maximum demand of a resistive load. If unexplainable overloading occurs in a network/grid with high penetration of photovoltaic solar energy, reactive power flow should be assessed.

In [3], it was found that with a high number of unity power factor rated inverters connected to a grid, the overall impact of reactive power flow was low with the mix of types of inverters used. Some inverters consumed reactive power while others supplied reactive power.

INVERTERS WITH REACTIVE POWER SUPPORT

According to [1] regulation of voltage and frequency will become increasingly difficult with high penetrations of unpredictable renewable energy delivered to the distribution system. It may be required for inverters to have the ability to assist with reactive power compensation or absorption to support the voltage or frequency of the grid, even if the real power output from the photovoltaic system is compromised.

IEC 61850-90-4 provides standards for information exchange between power converters, connected to the distribution system (through a consumer or directly), and utility suppliers or other entities tasked, with managing Volt, VAr and Watt capabilities of these converters [9]. This standard will provide a control method for the utility suppliers to control the grid connected inverters to maintain voltage and frequency on the distribution systems. One of the functions provided in the IEC 61850-90-7 is the Volt-VAr function for an inverter. This function will allow the distribution system operator to control reactive power from a photovoltaic system from minimum to maximum depending on the grid voltage. When the photovoltaic system is supplying maximum reactive power it will have to compromise the real power supplied to the grid [9]. Other functions of the IEC 61850-90-7 are the Commanded Power Factor Function (INV 3), Dynamic Reactive Power Support (TV 31) and WATT-Power Factor Function (WP 41-42) [9]. All these functions will require an inverter that can operate at low power factors when required.

According to [12] and [13], control methods that allow inverters to operate like virtual synchronous generators are more desirable as they control the real power and reactive power to achieve grid support functions. In addition to the real and reactive powers (PQ) transfer controlling method of inverters, [14] indicates the use of cascaded h-bridge inverters for use in medium voltage network to achieve grid support functions.

CONCLUSION

This paper has shown the potential importance of adequate power factor correction if an inverter with unity power factor rating is applied. This can be due to the electricity usage charge of a penalty of having a low power factor independent, of the amount of reactive power consumed or supplied, or under certain circumstances, an increase in the apparent power when the photovoltaic system is generating. At times, such as night, when there is no photovoltaic output, the inverter filters will supply reactive power. This could conceivably cause grid issues, but this has not been investigated here.

Distribution system designers should consider the concept of reactive power flow and negative power factor for systems with the likelihood of future high photovoltaic energy penetration levels.

REFERENCES

[1] S. Gonzalez, J. Neely and M. Ropp, "Effect of non- unity power factor operation in photovoltaic inverters employing grid support functions," 2014 IEEE 40th Photovoltaic Specialist Conference (photovoltaicSC), Denver, CO, 2014, pp. 1498-1503.

[2] C. Koch-Ciobotaru, L. Mihet-Popa, F. Isleifsson and H. Bindner, "Simulation model developed for a small-scale

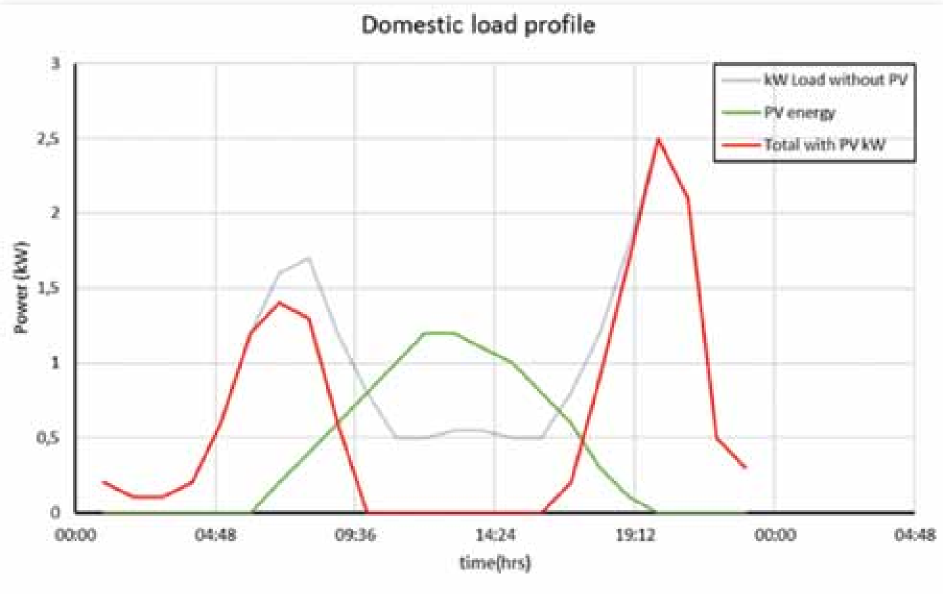


Figure 8: Typical load profile for a residential house with a 1200 W grid-tied photovoltaic system.

photovoltaic system in distribution networks," 2012 7th IEEE International Symposium on Applied Computational Intelligence and Informatics (SACI), Timisoara, 2012, pp. 341- 346.

[3] A. Spring, G. Wirth, G. Becker, R. Pardatscher and R. Witzmann, "Grid Influences From Reactive Power Flow of Photovoltaic Inverters With a Power Factor Specification of One," in IEEE Transactions on Smart Grid, vol. 7, no. 3, pp. 1222-1229, May 2016.

[4] G. Ertasgin, D. M. Whaley, W. L. Soong and N. Ertugrul, "Low-pass filter design of a current-source 1-ph grid-connected photovoltaic inverter," 2016 57th International Scientific Conference on Power and Electrical Engineering of Riga Technical University (RTUCON), Riga, 2016, pp. 1-6.

[5] L. Jiang, Q. Chen and X. Ren, "Analysis of a novel coupled inductor for LCL filter in grid-connected inverter," 2016 IEEE 2nd Annual Southern Power Electronics Conference (SPEC), Auckland, 2016

[6] H. Hu, Q. Shi, Z. He, J. He and S. Gao, "Potential Harmonic Resonance Impacts of photovoltaic Inverter Filters on Distribution Systems," in IEEE Transactions on Sustainable Energy, vol. 6, no. 1, pp. 151-161, Jan. 2015.

[7] B. Wang; Y. Xu; Z. Shen; Z. Jibin; C. Li; H. Liu, "Current Control of Grid-Connected Inverter with LCL Filter Based on Extended-State Observer Estimations Using Single Sensor and Achieving Improved Robust Observation Dynamics," in IEEE Transactions on Industrial Electronics , vol.PP, no.99, pp.1-1

[8] A. Reznik, M. G. Simões, A. Al-Durra and S. M. Muyeen, "LCL Filter Design and Performance Analysis for Grid-Interconnected Systems," in IEEE Transactions on Industry Applications, vol. 50, no. 2, pp. 1225-1232, March- April 2014.

[9] IEC 61850-90-7 Object models for power converters in distributed energy resources (DER) systems, edition 1 2013

[10] SeungGyu Seo, Yongsoo Cho and K. B. Lee, "Design of an LCL-filter for space vector PWM in grid-connected 3- level inverters system," IECON 2016 - 42nd Annual Conference of the IEEE Industrial Electronics Society, Florence, 2016, pp. 2259-2264.

[11] A. Aapro, T. Messo and T. Suntio, "Effect of single- current-feedback active damping on the output impedance of grid-connected inverter," 2016 18th European Conference on Power Electronics and Applications (EPE'16 ECCE Europe), Karlsruhe, 2016, pp. 1-10.

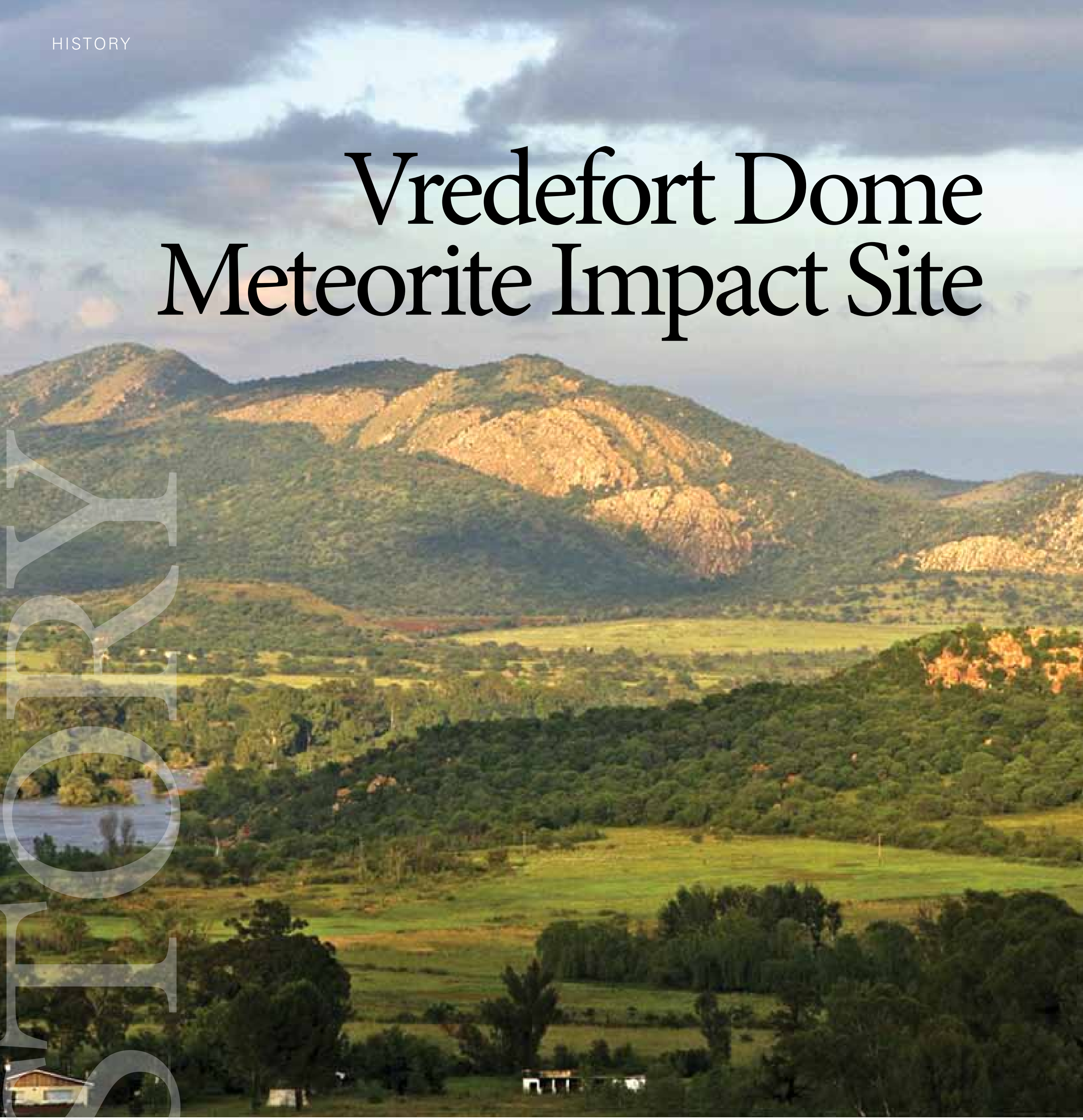
[12] S. M. L. Kabir, "A simple method of controlling real and reactive power for a grid-tied inverter," 2016 5th International Conference on Informatics, Electronics and Vision (ICIEV), Dhaka, 2016, pp. 224-228

[13] Mingxuan Li et al., "A power decoupling control strategy for droop controlled inverters and virtual synchronous generators," 2016 IEEE 8th International Power Electronics and Motion Control Conference (IPEMC-ECCE Asia), Hefei, 2016, pp. 1713-1719.

[14] J. Lamb and B. Mirafzal, "Active and reactive power operational region for grid-interactive cascaded h-bridge multilevel converters," 2016 IEEE Energy Conversion Congress and Exposition (ECCE), Milwaukee, WI, 2016, pp. 1-6

[15] H. Hu, Q. Shi, Z. He, J. He and S. Gao, "Potential Harmonic Resonance Impacts of photovoltaic Inverter Filters on Distribution Systems," in IEEE Transactions on Sustainable Energy, vol. 6, no. 1, pp. 151-161, Jan. 2015.

[16] Tenaga Nasional Berhad, "Charges and Penalties", webpage, https://www.tnb.com.my/commercial- industrial/charges-penalties, 11/5/2017 wn



Vredefort Dome Meteorite Impact Site

Over the years, several geographic studies had been carried out. In 1937, two scientists, John Boon and Claude Albritton Boon, after a study of the region, suggested that the Vredefort structure was the scar of an ancient meteorite impact. This has been accepted by the wider scientific community and is the focus of many earth scientists' studies since then.

It is believed that a meteorite, at least 10 to 15 km in diameter (possibly even as large as Table Mountain), travelling at more than 20 km/second (> 72,000 km/hour), penetrated

BY | DEREK WOODBURN | FSAIEE

Vredefort is a small town (approximately 3,000 residents) in the Free State province of South Africa. The town was established in the mid-1870s on the Visgat Farm. The owner, feeling grateful for the peaceful outcome of a threatened war between the republics of the then Orange Free State and Transvaal in 1857, named it Vredefort; which means 'peaceful fort'. The town is situated on the now named Vredefort Dome.

the earth's surface and exploded some 25 km below ground. It distorted the deep lower strata, which then rebounded with an elastic, explosive force, blasting out vast volumes of rocky material into the air. The earth reacted as if it were a liquid and formed a series of concentric layers of crater rim structures, reaching 300 km in diameter (from today's Welkom in the South to Johannesburg in the North).

The central impact structure possibly reached 10 km in height (higher than Mt Everest at 8,850m). Further, it is believed that the temperature resulting from the impact explosion could have reached over 20,000˚C. The central part of the upsurge formed the "dome" in the centre, such as one finds formed by large drops of water in a pond. The present-day town of Vredefort is the town closest to the impact, and gave the structure the name "Vredefort Dome Meteorite Impact Structure", or "Vredefort Dome" for short.

Vredefort Dome

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Map of South Africa indicating the impact site.

The Vredefort Dome Meteorite impact site has been eroded over the estimated 2023 million years since the impact occurred, and very little surface evidence of the impact is now visible.

Due to the enormous energy generated by the impact, it is believed that it could have taken hundreds of years for the impact material to cool down and return to solid matter. The resulting vast cloud of dust, from the explosion, probably encircled the Earth, generating an Ice Age that lasted well in excess of 10 years.

At the time of the impact, it is thought that the only form of life existing on Earth were single cell organisms called stromatolite. It is possible that one effect of the explosion may have been the splitting of some cells, leading to the formation of multiple-cell life, which eventually resulted in higher forms of life (evolution theory). The first hard-bodied creatures probably appeared about 1,600 million years after the impact, with the age of dinosaurs occurring a further 500 million years after that.

The immense force of the explosion may also have resulted in the tilting of the Earth on its axis, providing us with seasons.

Slabs of granite, formed at the time of the impact, and now mined in that area for export, show rounded chunks of quartz, fused in a matrix of impact friction and melt formation, with varying speeds of molten flow, creating different colours.

The impact of the shock-wave may have triggered fractures in the crust of the earth, which could possibly have resulted in the later splitting of the surface of Gondwanaland (the supercontinent that was in the Southern Hemisphere) into the currently existing continents.

In mid-1991, the discovery of shatter cones in the bed of the Vaal river, revealed that it was actually a meteor impact site, and not volcanic, as these rare geological formations only occur in the bedrock of an impact site. More recent satellite images reveal similar crater images on the surface of the moon. This site is the biggest and eldest meteorite impact structure that geologists have discovered on the Earth.

The subsequent erosion of the site, occurring over thousands of millions of years, removed about 10 km in height of material from the crater rim structure. This formed a tilted rock basin which, with the discovery of its gold, became the Witwatersrand. It is also possible that the tiny particles of gold deposits may have been fused together by the blast and high temperature into small nuggets; these were what was discovered by prospectors in the early 1880's. The erosion filling of the impact basin enables the Vaal River to flow right through the dome site on its way to the Atlantic Ocean, and not end up as a vast lake in the middle of the impact crater site.

The explosion appeared to have aggregated magnetic particles, concentrated to the extent that pilots flying over certain areas of the crater rim structure have their flight compasses disturbed for a period on their flight path. This as a result of the magnetic distortion caused.

If a meteor of a similar magnitude were to strike the Earth today, it is probable that nearly all life on earth could be wiped out by the resulting explosion.

In July 2005, a representative portion of the impact structure was declared a UNESCO World Heritage Site (one of 1,052 in the World, and it is South Africa's seventh World Heritage site). An Interpretation Centre was created in 2011, intended to be a sister site to the Cradle of Humankind, north of Johannesburg. Some R11 million was allocated for this project, located on a dome-

like rocky feature just outside the town of Vredefort. Sadly, this has not come to fruitition. However, it appears that poor project management has led to the complex becoming a structural disaster, and the building started falling apart before it was ever opened. It was said that, as a result of steel reinforcing being omitted, some of the floors separated from the supporting columns, and the roof split open.

The intended exhibition material, which had taken over a year to assemble, was never housed in the centre. The Centre was therefore never opened. In addition, no funding had been provided for the internal exhibits and for staffing.

The entire World Heritage site is privately owned, and is not generally accessible to the public other than by prior arrangement. It is recommended that registered tourist guides be employed to make your visit worthwhile. On a recent visit to the area, when exploring the town of Vredefort itself, the author was intrigued to realise that very few of the local people he approached for information knew anything about the significance of the site, and what "the dome", or the World Heritage Site, was all about.

The author gratefully acknowledges the help of Mr Christo Meyer, Official Guide to the region, in the compilation of this article. wn

The Earth Heaved and Melted.

WATT? is a forum related specifically to the industrial and commercial electrical sector.

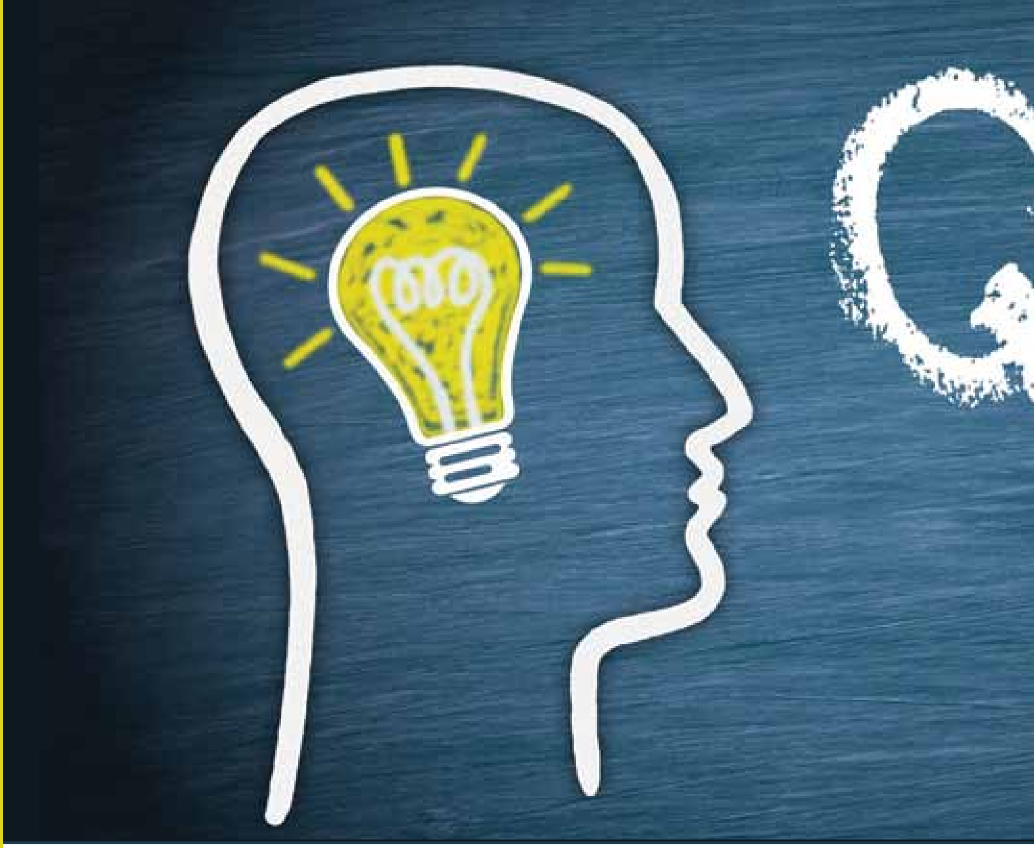
Do you have any burning questions, topical issues or points of interest about the electrical industry, from the perspective of a contractor, supplier or professional service provider? Submit your comments, thoughts, ideas, suggestions or questions for the attention of our industry experts, and these will be addressed in a future issue of the magazine. This is your forum, and we would like to hear from you!

WATT? is an opportunity for people on the ground to engage with each other and related professionals in an informative and friendly manner. This is a platform for you to discuss anything related to your particular sector, to highlight anything new, or to ask a specific question related to a technical topic or to engage in general industry issues. . Please note that we will not be considering anything related to the domestic sector, such as residential wiring.

We hope that this section of the magazine not only becomes a regular feature, but that it is widely read and distributed among your peers. Remember, it can only become a success with the full participation of our readers! Send your burning questions to minx@saiee.org.za - subject 'WATT?'.

We look forward to hearing from you.

- *Ed*



QUESTION ONE

What are the benefits of multiple synchronised diesel generator sets vs single standalone units?

ANSWER ONE

It is common practice to install a single generator to supply all the necessary back-up power in the event of a power outage. There are, however, a few benefits that need to be considered such as system reliability and availability, improved fuel economy and operational flexibility, which is achieved when installing multiple smaller generator sets in parallel.

System reliability and availability is improved when installing more than one generator set in parallel onto a common bus; for example in the unlikely event that one generator does not start when required the second unit will start. If careful consideration is given at design stage the system can be designed to shed less critical load and supply all essential load on just one generator. This would mitigate a total power outage as would have been experienced if the system was designed with just one generator.

Operational flexibility is an added advantage when supplying more than one synchronising generator set; for example, when supplying a single generator the standby power system is unavailable while undergoing service work or routine maintenance. When multiple sets are installed you will always have one unit available to supply critical loads in a breakdown or maintenance scenario.

You will avoid partially loading a single generator set when you have more than one set operating in parallel and will also save on fuel costs as the generator management system will ensure that only the required number of generators is running under low load scenarios.

A multiple sync system also allows the end user to expand the back-up power supply easily should the on-site load increase as the controls and paralleling switchgear is already in place.

QUESTION TWO

What is the benefit of sizing your generator set correctly?

ANSWER TWO

A generator set should not run at less than 30 to 40% of its rated load. If this does occur for extended periods of time the generator will be prone to liner glazing due to the engine not reaching the designed operating temperatures.

This, in turn, is costly to remedy and will lead to increased maintenance and repair costs.

A typical diesel fuelled generator engine is run most efficiently at an average of 70% load capacity.

QUESTION THREE

What is the difference between a standby, prime and continuous rated diesel generator set?

ANSWER THREE

In general, diesel generator sets are selected based on the application, duration of operation and loading requirements. It is critical to select the correct rated generator set to ensure the longevity of the unit and to keep within the standard warranty conditions of sale.

Standby power rated diesel generator sets are primarily used to supply emergency power for a limited time duration during a power outage. Standby rated generator sets have no overload capacity and are typically rated at 100% of the permissible power. The typical rating of a standby rated generator set should not exceed 80% average load factor and roughly 250 hours per year.

Prime power rating is the maximum power available at variable loads for an unlimited number of hours per year. The average load factor should not exceeding 70% of the prime power rating during any operation period of 250 hours. The generator set is capable of overload situations of 10% of the prime power rating for a period of no more than one hour in every 12 hour operating cycle.

Continuous power rating is used in applications where supplying power at a fixed 100% unvarying load for an unlimited number of hours each year. Continuous power rated units are most widely used in applications where there is no or limited power grid. wn

Information provided by Zest WEG Group

September

Movers, shakers and history-makers

COMPILED BY | JANE BUISSON-STREET
FSAIEE | PMIITPSA | FMIITSPA

1 SEPTEMBER

1914 Martha, the last known living passenger pigeon died at the USA's Cincinnati Zoo; she was named "Martha" in honour of USA's 1st First Lady, Martha Washington. Martha was 29 years old at the time of her death.

2 SEPTEMBER

1992 The first formal meeting between the ANC and NP government was held. The ANC mandated Cyril Ramaphosa to represent them, while the NP's representative was Roelf Meyer.

3 SEPTEMBER

1903 The first cable across the Pacific Ocean between Hawaii, Midway, Guam and Manila was completed and spliced at Manila, Philippine Islands. After testing, the first official message was sent the next day.

4 SEPTEMBER

aka Bright Idea Day

1899 1820 Settler, and early South African naturalist, Mary Elizabeth Barber died in Malvern, Natal Province. Barber was a remarkable woman with an extensive knowledge of natural history, especially botany and entomology. Barber aissisted in establishing the stratigraphic geology of South Africa, and initiated the examination of its ethnology, archaeology and palaeontology.

5 SEPTEMBER

1946 Freddie Mercury was born Farrokh Bulsara in Zanzibar, East Africa. His parents were Parsis from Bombay, India. At the age of seventeen he and his family left Zanzibar and settled in Britain. In 1970, he formed the band Queen with guitarist Brian May and drummer Roger Taylor. Queen went on to become one of the most successful bands of the 1970s and 1980s.

6 SEPTEMBER

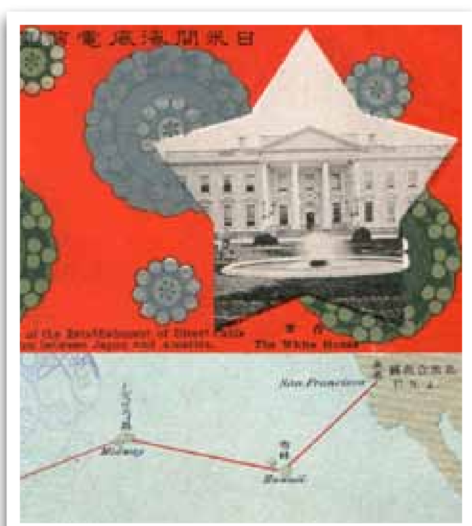
1977 The last remaining passenger ship of the Union Castle line, the Windsor Castle, left Table Bay for the last time. She was sold to Yiannis Latsis, Piraeus, renamed Margarita L (Panama flag); and was scrapped in August 2005.

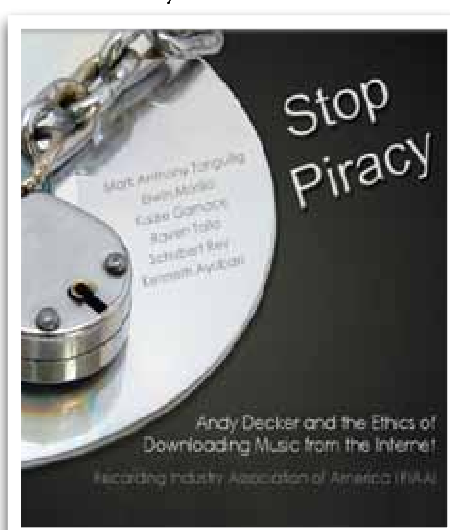
7 SEPTEMBER

1991 South Africa entered into international sport's competitions again; a gymnastics team was sent to the Artistic World Championships in the USA.

8 SEPTEMBER

2003 The Recording Industry Association of America (RIAA) sued 261 people for sharing music on Internet peer-to-peer networks. Eventually the number was over 30,000 people. This was done in an attempt reduce the amount of music being shared but, instead, generated a public backlash against the established recording industry.





9 SEPTEMBER

2000 For the first time the hole in the ozone layer over Antarctica stretched over a populated city after ballooning to a new record size. For two days the hole extended over the southern Chile city of Punta Arenas, exposing residents to very high levels of ultra violet radiation.

10 SEPTEMBER

1960 Ethiopian Abebe Bikila ran barefoot to become the first Black African to win gold in the history of the Olympic Games. In the process Bikila set a new world record at 2:16:2.

11 SEPTEMBER

1896 In reaction to an inquiry, officials in Pretoria replied that Johannesburg was named after Johann Friedrich Bernhard Rissik and Christiaan Johannes Joubert. This is the only document dealing with the origin of city's name. Rissik was a principal clerk attached to the office of the surveyor-general of the ZAR, while Joubert was a member of the Volksraad and head of the government's office of mines. It was on the recommendation of these two men that the land involved was declared a public gold-field.

12 SEPTEMBER

1998 Jacob Mofokeng, cruiserweight boxer of SA, won the World Boxing Union World Champion title.

13 SEPTEMBER

1905 The mayor of Cape Town, Hyman Lieberman, opened the Great Synagogue (Gardens Schul) in the Gardens, Cape Town.

14 SEPTEMBER

2004 Absa Bank handed an old warrant of arrest for Nelson Mandela, dated 18 May 1961, to the Minister of Arts and Culture, Dr Pallo Jordan. The warrant is now kept at the Liliesleaf Farm in Rivonia, which houses a library and archive.

15 SEPTEMBER

2004 According to Statistics South Africa, during the period between 1993 and 2002, there was a significant decrease in in the number of commercial farming units in South Africa. There were 12,162 less farming units in 2002 than there were in 1993, a decrease of 26%.

16 SEPTEMBER

1961 Typhoon Nancy, with possibly the strongest winds ever measured in a tropical cyclone, made landfall in Osaka, Japan, killing 173 people.

17 SEPTEMBER

19** The stork landed with Minx Avrabos – **watt**nows' Managing Editor.

2015 The US National Oceanic and Atmospheric Administration reported that the 2015 Northern Hemisphere summer was the hottest on record.

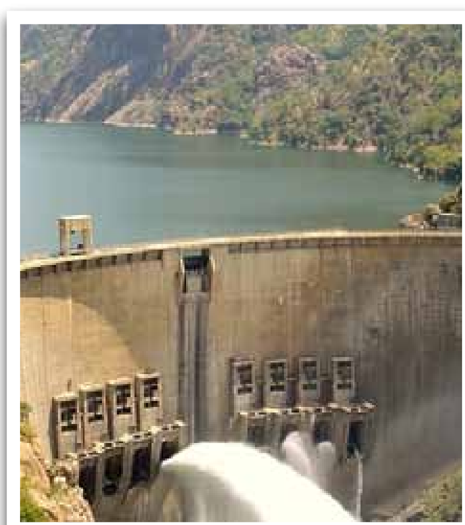
18 SEPTEMBER

1997 Dr Mark Erdman and his wife, Arnaz Mehta, discovered a coelacanth in a fish market in Manado on the island of Sulawesi, Indonesia while on honeymoon. Arnaz noticed a large, strange-looking fish being wheeled by in a cart. Dr. Erdmann immediately recognized the fish as a coelacanth and excitedly photographed it. Genetic studies suggest that this coelacanth is a newly recognised species, Latimeria manadoensis.

19 SEPTEMBER

is International Talk Like A Pirate Day.

1969 Four agreements relating to the construction of the Cahora Bassa Dam, in Mozambique, were signed in Lisbon. The main one being between the governments of South Africa and Portugal.



SEPTEMBER

continues from page 63

20 SEPTEMBER

2000 Dimension Data, the information technology long-time darling of the Johannesburg Stock Exchange (JSE) and London Stock Exchange, reached an all-time high of R70 per share and became the 3rd-biggest company on the JSE.

21 SEPTEMBER

– aka Wife Appreciation Day

2004 Catherine Labuschagne, aged 25, made history when she became the first woman fighter pilot in the world to fly a Gripen fighter jet. She did this during the opening of the African Aerospace and Defence Air Show at the Waterkloof Air Force Base.

22 SEPTEMBER

2004 George Teboho Mokgalagadi, with his hair dyed golden, won a Paralympic World Record and a gold medal for the 100m sprint in his first international competition at the Olympic Stadium in Athens, Greece.

23 SEPTEMBER

1983 Gerrie Coetzee, SA heavyweight boxing champion, won the World Boxing Association (WBA) title in the US by knocking out American Michael Dokes to become the first South African boxer to win a world heavyweight title.

24 SEPTEMBER

1660 Jan van Riebeeck writes to Otto Jansz on Robben Island, enquiring about the number of sheep on the island and whether he needs more, and also telling him to tend properly to the lighthouse.

25 SEPTEMBER

1907 The railway line between Cape Town and George was completed.

26 SEPTEMBER

2004 Former SA president and long serving political prisoner, Nelson Mandela, was voted the Greatest South African in a television show that had the country nominate their 100 most favourite personalities.

27 SEPTEMBER

2006 Andre P. Brink was one of twenty-eight recipients who received the country's highest honours at the eighth presentation of National Orders by President Mbeki at the Union Buildings.

28 SEPTEMBER

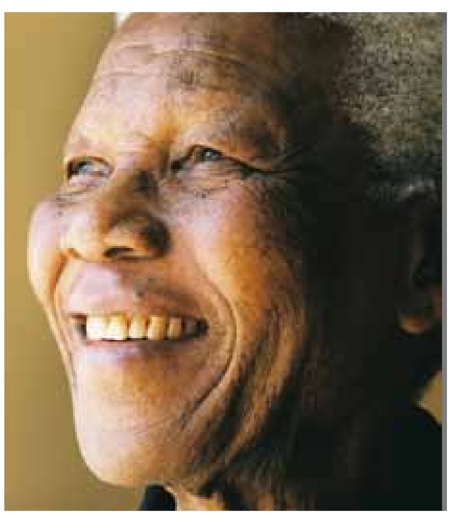
1902 Johannesburg mining authorities announced that 15 000 applications per week for gold mining permits were being received.

29 SEPTEMBER

2004 Evidence found at Barberton confirms theory of life on earth as early as about 3.4 billion years ago.

30 SEPTEMBER

2004 A fire virtually destroyed the historic Wanderers Cricket Club in Johannesburg, reducing to ash irreplaceable items like historic documents, photos, trophies and records. The fire, battled by seven fire crews, started in the kitchen but soon spread. wn



SEPTEMBER | OCTOBER | NOVEMBER 2017

SEPTEMBER 2017

6 - 7	Design Of Economical Earthing Systems	Johannesburg	roberto@saiee.org.za
11	66th Bernard Price Memorial Lecture	Western Cape	www.saiee.org.za
12 - 18	Advanced Microprocessor Based Power System Protection Course	Johannesburg	roberto@saiee.org.za
14	66th Bernard Price Memorial Lecture	Nationwide	www.saiee.org.za
19 - 21	SAIEE SmartGrid Conference	Midrand	www.saiee-smartgrid.co.za
19 - 22	Managing Projects Effectively	Johannesburg	roberto@saiee.org.za
20 - 21	Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
26	Fluke Proactive Maintenance Training	Johannesburg	www.saiee.org.za
27 - 29	Measuring the impact of energy optimisation projects	Johannesburg	roberto@saiee.org.za
28 - 29	Arc Flash	Johannesburg	roberto@saiee.org.za
29	Western Cape Centre Dinner & Dance	Cape Town	www.saiee.org.za

OCTOBER 2017

2 - 3	Optical Fibres, Cables & Systems Fundamentals	Johannesburg	roberto@saiee.org.za
3-5	FTTH Council Conference	Cape Town	www.ftthcouncilafrica.com
8-11	AMEU Convention	Port Elizabeth	www.ameu.co.za
9-11	International Water Association IWA Specialist Conference (IWAIWASP)	Skukuza	www.iwa-network.org
11 - 12	Fundamentals of Practical Lighting Design	Johannesburg	roberto@saiee.org.za
17-18	African Rail Evolution (ARE)	Durban	www.rail-evolution.com
18 - 19	Core Financial Management Skills for Engineers	Johannesburg	roberto@saiee.org.za
18-19	ELPA Installer's Exam	Johannesburg	www.elpa.org.za
22	AfrikaBot	Centurion, JHB	michael@uj.ac.za
25 - 27	Smart Meters for Smart Grid Training	Johannesburg	roberto@saiee.org.za
25 - 27	MV/HV Regulations for Authorised Persons	Johannesburg	roberto@saiee.org.za
27	SAIEE Annual Banquet	Wanderers	www.saiee.org.za
31	Internet of Things (IoT)	Johannesburg	roberto@saiee.org.za

NOVEMBER 2017

08	Sub Saharan Africa Power Summit 2017	Nationwide	www.saiee.org.za
08 - 09	Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
08 - 10	Planning Strategic Feasibility Studies	Johannesburg	roberto@saiee.org.za
14	Advanced Microprocessor Based Power System Protection	Johannesburg	roberto@saiee.org.za
14	The 8th Southern Africa Regional Conference	Western Cape	www.saiee.org.za
27	Overhead Lines Construction Management Course	Kwazulu-Natal	roberto@saiee.org.za
28	SA Energy Storage 2017	Johannesburg	www.energystorage.co.za

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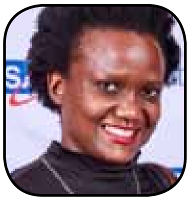

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Chairman | Joyce Mtimkulu

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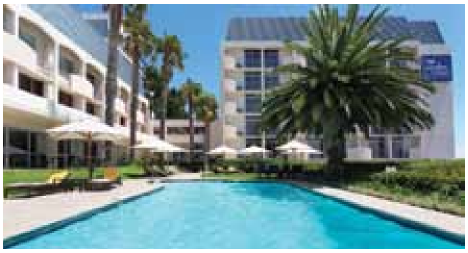
SOUTHERN SUN CAPE SUN

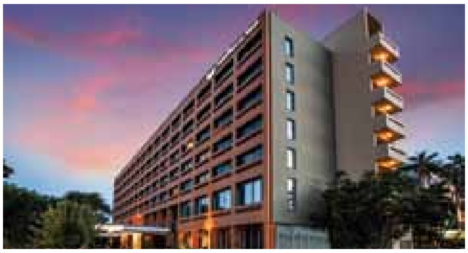
SUNSQUARE CAPE TOWN GARDENS

SOUTHERN SUN THE CULLINAN



GARDEN COURT NELSON MANDELA BOULEVARD

SOUTHERN SUN WATERFRONT CAPE TOWN



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