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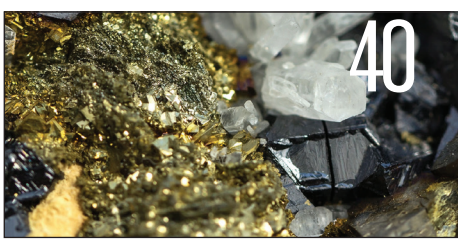

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SAIEE

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Dear Valued Readers,

I cannot believe we are only a few weeks from Christmas which means it's close to year-end and the silly season.

Due to circumstances beyond our control, we were unable to produce **watt**now's September's edition for which we apologise. To make up for it this month, this is a bumper edition combining both September and October's themes – Mining and Automation.

We start with *"Mining Engineering – some perspectives on managing risk"* which was written by SAIMM President 1995-1996, Mr Don Ross-Watt. Find this on page 26 as well as *"Geochemical mapping of drill core samples"*, our second feature, read this on page 32.

Our first Automation feature, on page 44 *"Automation & AI – Implications for African Development prospects"* discusses the some of the many pessimistic forecasts about the capacity of automation and Artificial Intelligence to replace a lot of workers very fast.

Also is included in the article following on from our first ST-Talk (SAIEE Technical Talk), *"Protection and Prevention of Fires caused by Power Transformers"*, written by Hosea Kwena. Here he discusses at the ideal way of keeping our electricity supply safe with the correct fire prevention methods.

Our second ST-Talk article, written by Quentin Louw, *"The impact of Non-technical Losses"* has him, as a South African comparing the South African figures to global trends. Find this informative article on page 62.

Dudley Basson did not disappoint with his historical article on Stirling Megawatts – read this on page 70.

The SAIEE National Conference is around the corner – and if you haven't booked your ticket yet (there is a considerable saving if you are an SAIEE Member) then do it soon. We are also combining the Annual SAIEE Awards and the National Students' Project Competition at the same event. The conference programme has been finalised recently - check out all the other activities we have planned for the jam-packed 3-day conference we promised you! Book your tickets today – and be part of engineering an Africa for the future – www.saiee-conference.co.za.

Herewith your Sept/Oct issue – enjoy the read.

2020 SAIEE going forward

Dear Valued SAIEE member,

"It was the best of times; it was the worst of times…"
That was how Charles Dickens started when penning his classic novel, *"A Tale of Two Cities"*.

It is, indeed, in the very same mood that we find ourselves engaging with you this month. There is more than enough in the world around us that can make us cynical, however, the opposite also holds true. Depending on which door of opportunity you are looking at, one's outlook tends to be dominated thereby.

Dwelling on the open door, I can assure you that we, as the SAIEE, are positioning ourselves for the future and aligning ourselves accordingly. The end of 2019 is nigh and, with it, the beginning of the new 2020 financial year for the SAIEE. The 2020 operational budget has been approved by Council, together with the latest membership fees.

You should have already received communication regarding the 2020 Membership fees (see page 83). These fees are due from December 2019, and you will be receiving invoices and statements to that effect. For the 2020 financial year, herewith are the changes as approved by the SAIEE Council:

- Membership fees can be paid off in recurring payments. Members taking up this offer must schedule these recurring payments with their bank (on the banking app/in the bank). Should the membership fees be paid in full by 31 March 2020, the early bird discount will apply. Should the recurring payments for membership fees occur after 31 March 2020, the early bird discount will not apply anymore, and members must use the "Annual Subscriptions paid after 31 March 2020" column to calculate their recurring fees.
- Your favourite magazine (yes, the one you are reading currently, the wattnow) will only be published online going forward. Should you wish to receive a hardcopy, you will need to pay an additional amount of R1 100 by 1 January 2020. This will be subject to a minimum offer uptake of 500 (minimum printing quantity).

We will be launching a brand-new member benefit in the form of a reward program called "Charge" soon. Watch this space…!

You are welcome to email me (leanetse@saiee.org.za) if you have any queries.

Regards

Leanetse Matutoane
Operations Manager
SAIEE

The WOAN – to be or not to be

GEORGE DEBBO
2019 SAIEE PRESIDENT

The concept of having a Wholesale Open Access Network (WOAN) has been part of telecommunication policy discussions in South Africa for some time; and has been reaffirmed in the latest policy directive released by the Minister of Communications and Digital Technologies.

WOAN has elicited much discussion and debate, and so I thought it would be appropriate to explain what WOAN is, how it came about, and why all the discussion around it.

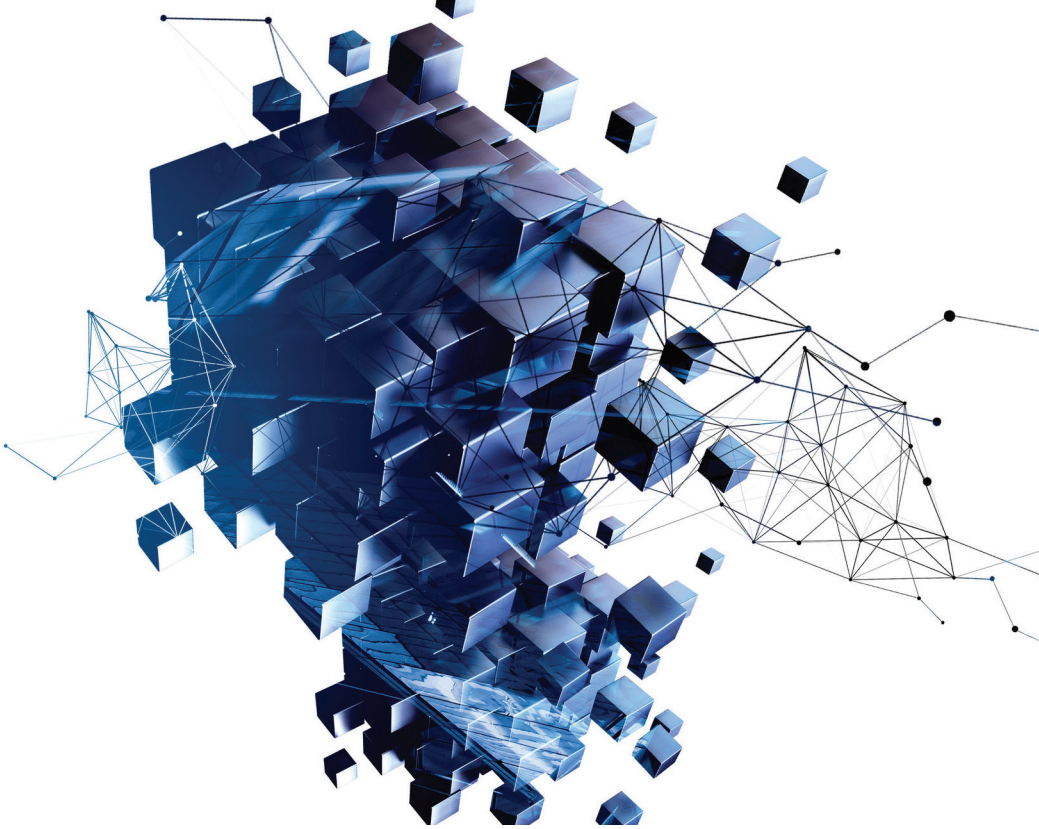
The concept of a WOAN was conceived under the leadership of Siyabonga Cwele, former Minister: Telecommunications and Postal Services, to enable benefits from using information and telecommunications technology while doing this at an affordable level. At the time the idea was to create a monopoly wholesale network which would be operated and funded as a private sector owned and managed consortium, and from which numerous service providers would lease capacity to serve their customer base. The thinking was that moving competition from infrastructure to services would reduce the cost of communications, both voice and data.

Although this idea does have merit, some conditions raised many alarm bells at the time. These include:

1. that all new spectrum, still to be allocated, be housed within the WOAN. This would include the high demand spectrum in the 700, 800, 2600 and 3500MHz bands that the existing operators are desperate for so that they can expand coverage and capacity on their existing networks. In the interim, and because no spectrum has been allocated, existing operators have had to re-farm spectrum from their 2G and 3G networks, as well as densifying their systems by building smaller cell sites at significant additional capital investment.
2. it was even suggested at one point that regulation would be enacted forcing all telecommunication operators within South Africa to return spectrum already allocated, this after they have spent billions of rand in network infrastructure investment.

Not surprisingly the response from the existing incumbents was extraordinarily negative which resulted in numerous discussions, both in public forums and through lobbying the Department of Telecommunications and Postal Services in order to persuade the Minister to re-think his strategy.

Interestingly two existing operators supported the WOAN these being Telkom and Cell C.



The concept of having a monopoly single wireless network (SWN) or WOAN is not unique to South Africa. Other countries have tried deploying similar networks with varying results. Mexico created a WOAN (called Red Compartida) to break the market dominance that Carlos Slim's América Móvil had on the industry. The operator has an 82% market share. The creation of Red Compartida was mandated in the constitution, and the organisation was given exclusive access to 90MHz of bandwidth within the 700MHz band. The allocation of this bandwidth was linked to the "Digital Dividend" that resulted from the migration of analogue TV to digital TV. The contract was signed in 2017, and today only 35% coverage has been achieved. This is expected to increase to 50% by the middle of 2020. It is still too early to see the impact that creating the WOAN has had on the industry, but there have been some small changes including the stimulation of additional capital investment on the part of América Móvil. The creation of the WOAN has yet not had an impact on reducing the price of services though.

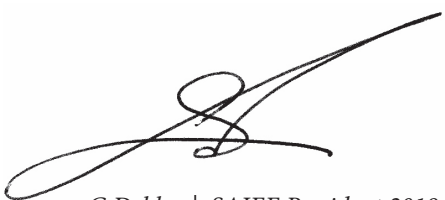
Another example is Rwanda. The Global System for Mobile Communications Association (GSMA), that represents the interest of mobile operators worldwide, has indicated that this WOAN has not delivered what was promised. It was implemented in 2014, but the 4G coverage objective has still not been met. The low pricing objective has also not been met, and therefore, the service take-up is slow. There have also been no new mobile operator's starting up, and thus competition in this country's mobile market remains unchanged.

With the change of administration, Minister Stella Ndabeni-Abrahams has been brought in to take over the running of the Department of Telecommunications. In late August 2018 she released a new ICT policy directive that addresses spectrum allocation which still retains the WOAN but at a reduced focus. The policy directive proposes that spectrum be allocated as per the 2017 CSIR study which determined what range should be awarded to the WOAN.

Other WOAN proposed conditions include:

- existing operators cannot bid for the WOAN licence unless they do so through an entity that is "functionally separated" from their existing business;
- operators that procure their high-demand spectrum must acquire 30% of their capacity from the WOAN; and
- operators will be required to make their infrastructure available to the WOAN at wholesale rates.

Despite negative sentiments directed towards the creation of a WOAN, in my opinion, I believe the government should go ahead with its implementation. The risks have been reduced so that it will not consume all high-demand spectrum as was initially suggested. It will also have the benefit of stimulating infrastructure investment and therefore create job opportunitie,s which the country desperately needs under the current economic conditions. The fact that it has not worked elsewhere should also not be a reason not to try locally. There are many examples of successful local developments that people initially thought would not work, for example, the use of pre-paid services.



G Debbo | SAIEE President 2019
Pr. Eng | FSAIEE

INDUSTRY AFFAIRS

SAIEE First ST-Talk on Lightning

The first of the extremely exciting ST-Talks (SAIEE Technical Talks), based on the August issue of the wattnow magazine, Lightning, kicked off on the 26th September at the SAIEE Head Office.

The talks were sponsored and presented by Prof. Chandima Gomes from Wits University on lightning protection to the informal sector and informal structures, and Alexis Barwise from Lightning Protection Concepts on the lighting protection to the home.

The idea of the talks is to present to anyone interested in the theme topic, which is a short presentation ± 15 minutes with a quick Q&A after.

Eats and drinks where available after the sessions which made for great networking and just having an overall great evening.

The intention is to have an ST-Talk once a month. So be on the lookout for the announcement in the SAIEE correspondence to members, either in the form of an SMS or the newsletter.

Norman Maleka
National Sales and Marketing Manager
SEW-EURODRIVE (Pty) Ltd

African mines gear up with refurbishment service

A convenient and cost-effective option for ageing African mines, some of them 50 to 60 years' old, is to have their geared units professionally and cost-effectively refurbished by SEW-EURODRIVE (Pty) Ltd.

Supplementing its refurbishment capability, the drive engineering specialist can also offer a drop-in gearbox replacement service. Geared units are particularly difficult to refurbish or modify on mines, as their large size means that production has to be halted temporarily in order to gain access. This has a hugely negative impact on any mining operation's bottom line. Thus, many mines hold out on replacing these essential high-capex items for as long as possible. SEW-EURODRIVE (Pty) Ltd is now able to replace historically-inefficient worm gear units with the latest helical and helical bevel gearboxes, made from case-hardened steel for maximum durability. The major advantage for mining clients, in particular, is that no modification to or adjustment of the original geared unit is required. *"The drop-in replacement is based on a fabricated case that matches all critical dimensions of the existing gearbox exactly, and with improved mechanical and thermal ratings,"* SEW-EURODRIVE (Pty) Ltd. National Sales and Marketing Manager Norman Maleka highlights.

DEHN Africa Senior Engineer attains Professional Engineer status

Ivan Grobbelaar

It is important that engineers register in their different disciplines in order to promote public safety. The recent qualification of DEHN Africa's Senior Engineer, Ivan Grobbelaar, as a Professional Engineer underscores DEHN's commitment to responsibility and the best interests of the general public.

Grobbelaar has been working at DEHN Africa for two years and in July of this year, he attained the recognition of Professional Engineer (Pr. Eng) through the Engineering Council of South Africa (ECSA).

He clarifies, *"A professional engineer is someone who is certified to approve and sign off projects in terms of the Engineering Profession of South Africa Act 2000 (Act no.46 of 2000). Our industry - lightning protection and earthing - does not have many professional engineers currently. Therefore, my engineering status means that at DEHN, we can offer this service and stand out as a company that really specialises in, and dedicates ourselves to, public safety. This accreditation also holds an international merit in terms of the Washington Accord. This expands DEHN Africa's footprint."*

Hano Oelofse, Managing Director at DEHN Africa, adds, *"We are very pleased and proud of Ivan's achievement, which also takes place in the context of DEHN's development plan for young engineers. Having obtained his degree, Ivan was able to develop his knowledge to successfully integrate it with practical experience. Additionally, he now also has the ability to grow and mentor other young engineers to one day achieve professional registration."*

"As DEHN we really push to promote safer installations and designs in the industry. So we can now promote Ivan's qualification and approve lightning protection designs and installations on a legal basis, showing once again how we strive to go the extra mile in all our endeavours," concludes Oelofse.

Alstom's joint-venture Ubunye inaugurates its world class rail factory in SA

Alstom Ubunye rail factory, one of Alstom's joint-ventures in South Africa, was officially inaugurated on 17 October 2019, in Ekurhuleni, in the presence of the Premier of Gauteng, Mr David Makhura, Dr. Nkosindiphile Xhakaza, MMC (Member of the Mayoral Committee) for Finance and Economic Development in Ekurhuleni, the French Ambassador in South Africa, Mr Aurélien Lechevallier, and Alstom Chairman and CEO, Mr Henri Poupart-Lafarge, together with 100 guests and 565 employees.

Alstom, through its two South African joint-venture companies, Alstom Ubunye and the Gibela Rail Transportation Consortium, is proud to be part of the development of rail transportation in South Africa.

Through the two factories situated in Ekurhuleni, near Johannesburg, Alstom is committed to creating a sustainable future for the more than 1500 local employees.

Both JV's are well established South African companies, with local partners, more than 95% local employees, with unique skills and technology transfer programmes.

Besides its long-term ambitions for the country, Alstom is also making an impact on local communities through several social investment programmes.

"Since 2016 we embarked on a huge programme and investment to modernize the Alstom Ubunye factory in order to supply components for 150 trains to Gibela Rail, where the new PRASA trains are being built. The unique transfer of technology from our sites across the world has created a rail factory hub with world-class competencies.

We are confident in the future of South Africa and have established this industrial footprint with a long-term vision to be an African Rail Hub of excellence" said Henri Poupart-Lafarge.

Over the past 3 years, the factory has been transformed in its entirety to ensure Alstom Ubunye can meet the demands of its customers. A significant investment has been undertaken in upskilling employees and installing state of the art equipment such as advanced robot technology. The factory has recently been certified to EN 15085 CL1 and ISO 3834-2, the highest welding certification level in the industry, globally. This CL1 certification applies to safety critical components such as bogie frames, End Under Frames (EUF) and anti-intrusion boxes.

In Full Nominal Mode Ubunye will deliver 62 bogies, 62 end under frames, 20 traction cases and 10 Static Inverters per month. It will also manufacture looming, cubicles and PACIS (Passenger Public Address, Closed Circuit Television and Information Systems), and prepare to serve the expected increasing demand for rail innovation in Sub-Saharan countries.

INDUSTRYAFFAIRS

Thakothaba - Women Month Event

The South African Institute of Electrical Engineering (SAIEE) Central Gauteng Centre collaborated with the Eskom Young Professionals to celebrate Women's Month 2019. The event took place on the 21st August and was intended to motivate, encourage and impact the learners (girls and boys) of grades 10 and 11.

Ms Maite Sako, Senior Engineer, Asset Integration and Systems Operator, is an SAIEE Member and the Vice-Treasurer for the SAIEE Central Gauteng Centre.

Maite's discussion with the learners focussed on SELF-: worth, discovery and acceptance. She told the learners that each one of them has a purpose here on earth; accept yourself! Knowing ourselves and accepting the way we are is one of the greatest successes in life.

Each person is worthy of success, no matter their background. We need to take charge of our lives and make sure that we do our best at every opportunity. What matters the most is what is inside of us: - our thoughts, drive, desires, the choices we make, etc. We are the only person who can make our dreams come true.

Maite then spoke to the learners about their Vision for themselves. She tasked each learner to go home and write their five-year plan on a piece of paper. How do they want to want to take part in building this beautiful nation? Whether it is in a health sector, engineering, education for whatever it may be. Writing it down will enable them to keep their focus and feed into their dreams.

The next topic she spoke about was Respect - the importance of respecting everyone around them. This includes parents,

neighbours, classmates, other adults and school teachers as well. In order to be respected, a person needs to be respectful.

Lastly, Maite spoke to the learners about their school results. Often school academic results are a person's first impression of them and therefore must speak well of their owner. Maite advised the learners to starve their distractions and feed their focus to ensure greater success.

The second speaker was Ms Mosley Lebeloane-Mokoena, who is a qualified Social Worker.

She spoke to the learners about taking care of their health and protecting themselves from the diseases, especially HIV/AIDS. Mosley also told the learners that they will make mistakes, and some of those may change their lives.

The third speaker, Ms Neo Mapapanyane, Systems Engineer, Operations Performance, at Eskom.

She spoke about career guidance and highlighted two key-points that learners should understand before registering at any institution. The first point emphasized the differences between the three types of higher institutions that they can enrol in after matric. The second point focused mainly on subject selection and careers that they could pursue based on their preference.

The last speaker, Mr Teboho Machabe, Senior Engineer, Operation Planning, Eskom the Chair of the SAIEE Central Gauteng Centre.

Teboho spoke to the learners about the importance of having a mentor in life and how one can identify or chose a mentor.

He talked about three critical lessons that they should never forget, namely:

- Reality - If it's too good to be true, it probably is.
- Be brave in your endeavours.
- Decide - if you don't make decisions, someone else will, and you will have to live with the consequences.

Building relationships with Chinese EPCs

The KSB team has reached out to Chinese EPCs in order to forge relationship to cooperate on numerous energy projects in Africa. Seen here are KSB MD Peter Weber, KSB Shanghai director of business development, Helen Ding, PowerChina East and Southern Africa representative, Chen Si, KSB Pumps and Valves regional project manager, Frikkie Botma, KSB Shanghai export manager, Liangxi Huang and KSB Pumps and Valves regional sales manager, David Jones.

SAIEE Eastern Cape Centre visit ELIDZ

Members of the SAIEE Eastern Cape Centre visited the East London Industrial Development Zone.

During September, the East London Industrial Development Zone (ELIDZ) hosted a few members of the SAIEE Eastern Cape Centre.

The Manager: Corporate Communications and Marketing, Sibusiso Ralarala welcomed our members and gave them an overview of the Industrial Zone in the heart of East London.

The ELIDZ was one of the first Industrial Zones (IDZ) in South Africa to be awarded a provision operator's licence in September 2002. The zone has come a long way since then.

Not only has it overcome various institutional and programme challenges to be where it is today, but it has, as the first operational IDZ in South Africa, helped to inform the South African government's Special Economic Zones (SEZ) programme to compile the policy framework.

Afterwards, the members were treated to a visit to the Science Technology Park where they were taken through to the Renewable Energy Training Facility.

In response to the current and expected future demand and growth within the "Green Economy" of South Africa, the Renewable Energy Centre of Excellence was set up within the East London Industrial Development Zone Science and Technology Park (ELIDZ). This was done in partnership with Master Artisan Academy (SA), and will be a catalyst and leader in the development and growth of skills within the sector, not only within the Eastern Cape, but also South Africa and Africa.

The Centre has been in operation since 2013 and focuses on the delivery of skills development programmes in PV, Solar Thermal and Wind Turbine technologies. The services provided by the centre are aimed at a number of target groups and stakeholders within the sector, namely:

- qualified artisans that want to up-skill towards renewable energy;
- school leavers preparing for career within renewable energy;
- skilled workers that need to be up-skilled to participate in both the construction and maintenance phases of various renewable projects in South Africa;
- management and decision–makers in both public and private sector; and
- current RIPPP providers announced, as well as potential investors in the area, to promote prototyping.

The ELIDZ's Science & Technology Park (STP) aims to facilitate creative, technical solutions to problems; thereby assisting companies adopt innovative approaches in all their operations. These could lead to new products and services, or a new improved version of an existing offering, through improved processes.

Interactive and attractive workspaces exist to aid in the creation of a functional innovation ecology that not only allows for an effective and efficient exchange of ideas, but could also result in the activation of a wide range of funding streams and joint partnerships which support innovation and commercialisation. This dynamic and supporting environment is designed to enable innovators to focus on developing innovations, while incubation support services assist in ensuring that the commercial, legal and intellectual property dimensions of operations are taken care of.

INNES HOUSE SAIEE MUSEUM VISIT

The Historical Section hosted 10 visitors from the Rand Aid Inyoni Lodge Retirement Village in Innes House in August 2019. The visit was organised by SAIEE Fellow Bill Bergmann.

The group were welcomed by members of the Historical Section Committee and given a conducted tour of the various rooms. There were questions and answers and discussions on the various displays of historical equipment. The tour lasted about an hour and a half and after some refreshments, the visitors returned to their village.

Members from the Rand Aid Inyoni Lodge Retirement Village visited the SAIEE Museum.

HV Test Receives ISO 45001:2018 Occupational Health & Safety Management System Certification

HV Test has successfully achieved certification to the first international standard for Occupational Health and Safety ISO 45001: 2018. This certificate has been granted after an intense audit by QAS International.

The new ISO 45001:2018 published in March 2018 by the International Organisation for Standardisation body (ISO), confirms excellence and good practices in Occupational Health and Safety Management Systems. This new standard puts special emphasis on prevention systems and on the companies´ global commitment for the development of a culture of prevention and continuous improvement in this field.

By achieving ISO 45001, HV Test continues to demonstrate its organisational resilience through proactive risk prevention, innovation and continual improvement. This certification guarantees that HV Test a clear focus on risks and opportunities for Workers Health and Safety management.

HV Test has also demonstrated its strengthened legal and regulatory compliance whilst achieving the highest safety standards of services across its supporting business functions and has demonstrated active employee engagement with health and safety and leadership commitment.

This fantastic achievement confirms HV Test's safety culture that is embedded within business objectives and strategic aims. The whole team at HV Test has worked very hard and shown great commitment towards achieving this standard.

For more info contact Liz da Silva,
Tel: 011 782 1010

INDUSTRYAFFAIRS

SAIEE Northern Cape Centre visits Droogfontein PV Plant

The SAIEE Northern Cape Centre (NCC) had the privilege of visiting the Droogfontein Photovoltaic (PV) Powerplant last month. With 23 members in attendance, and the Northern Cape being the hub of Independent Power Producers (IPPs), NCC Chairman, Ben Mabizela said: *"As part of the NCC activities, we wanted to understand the operations of a solar plant better, and decided to visit the Droogfontein PV Solar Plant"*.

The Droogfontein Solar Power project is located 20 km outside Kimberley, in the Sol Plaatje Municipality in the Northern Cape. It occupies approximately 100 hectares of land leased from the Droogfontein Communal Property Association. The facility generates electricity using 168 720 solar (PV) panels and feeds into the 132kV Eskom distribution system. Arising from the South African Government's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), Droogfontein Solar Power has signed a 20-year Power Purchase Agreement with Eskom as well as an Implementation Agreement with the Department of Energy.

The project mobilised construction teams in December 2012 and reached commercial operations date mid-2014. The solar power project generates approximately 85 458 MWh per year, supplying clean enough, renewable electrical energy to power more than 19 000 South African homes. The project received full environmental authorisation from the Department of Environmental Affairs in 2011 and has many environmental benefits such as reduced carbon emissions and water saving.

After the tour, the team, accompanied by Pieter Botha, Solar Technician, and Xavier Assegaai - Site Supervisor, joined them for refreshments and networking. *"Everyone enjoyed the visit with child-like enthusiasm and a heartfelt thank you goes out to the Droogfontein PV Solar plant for their hospitality"*, Mabizela concluded.

SAIEE
MPUMALANGA CENTRE

INTRODUCES A TECHNICAL TALK

ESKOM UNPLUGGED

BY CHRIS YELLAND

CEng, FSAIEE, managing director at EE Publishers

SYNOPSIS

The presentation will discuss electricity policy, planning, regulation and price trajectory in South Africa, and will consider whether these are fit-for-purpose in the rapidly changing energy environment we are in. The current structure of the electricity supply industry – generation, transmission and distribution – will be considered, to identify the fundamental structural problems, and their impacts on the wider economy. The three pillars of business sustainability – financial, operational and environmental – will be discussed, with reference to Eskom. Finally, the intended restructuring of Eskom and the wider electricity supply industry will be presented, and the envisaged benefits to the economy highlighted.

ABOUT CHRIS

Chris Yelland obtained a Bachelor of Science degree in electrical engineering from the University of Natal in 1976, and is the founder and managing director at EE Publishers (Pty) Ltd, the publisher of EngineerIT, Energize, Vector and PositionIT magazines.

Chris was the winner of the 2002 South African Bureau of Standards Media Award for "exceptional contribution to increasing the awareness of standardisation and related issues through the media".

In 2003, he won a merit award in the Energy category of the 2003 Siemens Profile Awards, "recognising journalistic contribution to excellence in the field of science and technology".

At the 2004 ABB Excellence in Technology Reporting Awards, Chris received the ABB Technology Journalist of the Year Award for 2004.

In 2009, Chris won the South African National Energy Association (SANEA) Journalism Award for "special efforts within the field of journalism to promote greater understanding of energy and its role in sustaining human endeavours".

In 2018, Chris was awarded the prestigious South African Institute of Electrical Engineers (SAIEE) President's Award for "in recognition of his outstanding contribution to the South African electrical engineering industry".

Chris is a fellow of the SAIEE, a senior member of the IEEE (USA), and a member of the IET (UK). He is also a registered Chartered Engineer with the Engineering Council in the UK.

DATE: 7 November 2019 **I** **TIME:** 17H00 - 20H00 **I** **VENUE:** SECUNDA SASOL RECREATION CLUB **I** SECUNDA
SAIEE MEMBERS ATTEND FREE **I** NON-MEMBERS PAY R100 **I** RSVP BY NO LATER THAN 30 OCTOBER 2019 - elyssa.spreeth@gmail.com

SAIEE BP Lecture Tour

With the well-anticipated 68th Bernard Price (BP) Memorial Lecture in September, father of the Ethernet, Prof Bob Metcalfe graced us with his presence, in a nationwide tour. The event kicked off in Johannesburg in the Great Hall at the Wits University in September 2019.

In Johannesburg, Professor Zeblon Vilakazi, Deputy Vice-Chancellor (Research and Postgraduate Affairs) welcomed Prof Metcalfe, SAIEE President George Debbo and guests. George Debbo introduced Prof Bob Metcalfe, as the father of the Ethernet, with his tour theme: Connectivity.

From left: Prof Sunil Maharaj (SAIEE Senior Vice President), Professor Zeblon Vilakazi, Deputy Vice-Chancellor (Research and Postgraduate Affairs) Wits, Prof Bob Metcalfe (BP Lecturer) and George Debbo (SAIEE President).

Prof Metcalfe, accompanied by George Debbo, visited the KwaZulu Natal Centre, the Eastern Cape Centre and ended off at the Western Cape Centre.

At the eThekwini Training Centre, in Springfield, Kwa-Zulu Natal Chairman, Jay Kalichuran opened the presentation with a welcome to the SAIEE President and Prof Metcalfe. The networking event after the talk was buzzing with excitement and Prof Metcalfe was inundated with questions.

Synopsis of Prof Metcalfe's presentation:
The single most important new fact about the human condition is that we are all connected. In just 50 short years, we have managed to connect half of the people on earth, which equates to four billion individuals. Such connectivity has created numerous challenges and then comes the Internet of Things which is going drive such connectivity into tens of billions.

Broadband connectivity is the fundamental enabler for today's digital world. Irrespective of the type of physical medium, Ethernet is the primary protocol that is used to deliver connectivity and consequently has become the prime enabler of the Internet. Ethernet is today 50 years old, having been conceived in 1969 as a network of university mainframe computers.

In simple terms, Ethernet provides the rules that dictate how network devices or nodes format and transmit data packets between one another. Prof Metcalfe invented the Ethernet on May 22nd 1973 in a memo that he wrote at the Xerox Palo Alto Research Centre. The IEEE standardised it in the early 1980s and commercialised shortly after that.

Ethernet has evolved over the past four decades from supporting local area networks at an enterprise level to providing the carrier-grade wide-area connectivity and performance quality needed for metropolitan, regional, national and international telecommunication networks.

The use of Ethernet for wide-area networks is called Carrier Ethernet and is an extension to enable telecommunication network providers to deliver Ethernet services to their customer by utilising Ethernet technology within their networks.

Ethernet has become the fundamental building block for Digital Transformation. This lecture provided insight into the history behind the development and evolution of Ethernet to where it stands today.

Prof Metcalfe, in his presentation, discussed how Ethernet will support the future connectivity requirements needed to drive emerging technologies.

Turbine Drive Train Overhauled In Just Six Weeks

In a recent major overhaul of a 70 MVA turbine generator set, Marthinusen & Coutts, a division of ACTOM (Pty) Ltd, contracted with South 32's Metalloys to take full responsibility for entire drive train refurbishment.

Working in collaboration with business unit ACTOM Turbo Machines, Marthinusen & Coutts completed the work successfully within six weeks. The electrical generation plant is at Metalloys' manganese plant in Meyerton, Gauteng. According to Mike Chamberlain, Marthinusen & Coutts' marketing executive, this achievement showcased the capacity of the divisions to take full control of large mechanical and electrical refurbishments. Chamberlain highlights that the customer did not want to split the responsibility for the complete generator and turbine drive train between separate contractors.

"Marthinusen & Coutts and ACTOM Turbo Machines' capabilities enable us to control the entire process, offering peace of mind to customers, coupled with optimised cost efficiencies," says Chamberlain. *"This also reduces customers' risk and managerial effort in dealing with multiple suppliers."*

The scope included a complete inspection of the turbine rotor and internal components, as well as runout and dimensional inspection on the rotor. Inspections incorporated glass bead blasting and non-destructive testing of many components. High-speed balancing of the 13 tonne rotor was conducted, and turbine rotor journals were repaired. White metal bearings were relined, and the thrust bearing was modified to improve fitment in the bearing casing. Positive material identification tests were conducted on all the studs, nuts and shaft seals.

Marthinusen & Coutts successfully completed a major overhaul on a 70MVA generator set.

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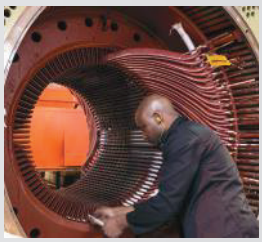

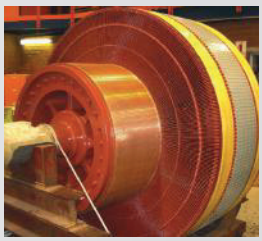

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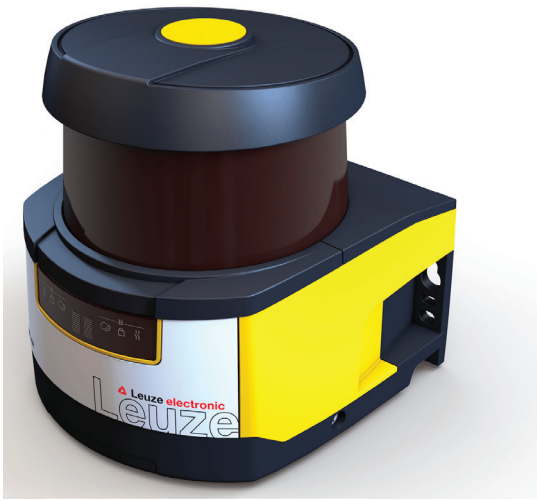
On Safe Paths With Leuze



When using the principle of triangulation for navigating automated guided vehicles (AGVs), vehicles are often equipped with two different scanners – one for safety and one for navigation. Now there is a more cost effective alternative - the new Leuze RSL 400 safety laser scanner.

This innovative safety laser scanner not only ensures that AGVs are operated safely by means of protective and warning fields, but also simultaneously captures the measurement values for the navigation software. This means that only one scanner is needed for both safety and navigation.

Available from leading sensor specialist, Countapulse Controls, the Leuze RSL 400 safety laser scanner makes use of the latest technology resulting in measurement values with an extremely high angular resolution and accuracy.

The measurement value output of the device is optimised for navigation software which functions in according with SLAM (Simultaneous Localisation and Mapping). These characteristics allow the Leuze RSL 400 to precisely determine the position of the AGV.

The navigation software contains an image of the operating area including all fixed boundaries. The current position of the AGV is calculated by comparing the measurement values to this map. This concept is referred to as natural navigation. With each revolution of its deflection unit, lasting 40 milliseconds, the safety laser scanner emits 2700 light pulses. These are scattered in all directions, and parts of the scattered light are transmitted back to the scanner. These are used to calculate the distance to an obstacle.

The more detailed and exact the measurement values of the scanner, the more precisely the AGV can navigate. With an angular resolution of 0.1, the Leuze RSL 400 can capture the environment in detail over the entire measurement range up to 50 metres.

This is achieved through a particularly narrow laser spot that maintains its perpendicular shape over the entire scanning angle. It also reduces incorrect measurements, the likes of which can occur on edges.

In addition to the angular resolution, distance values are also important. The Leuze RSL 400 offers an error accuracy of less than 30 mm resulting in high precision. Use of technology in the device has ensured that the values are not affected by the reflectance of the object, whether it is a reflector or a black wall.

The additional output of the received signal strength value for each beam allows autonomous detection of reflectors by the navigation software. When beams strike a reflector, the values differ greatly from any other environment. This makes simple and reliable detection possible.

Safety is also optimised with the Leuze RSL 400 scanner. The device offers up to 100 switchable protective and warning field pairs. The protective fields can be adapted to the respective movement and load conditions of the AGVs.

With these features and a maximum operating range of 8.25 metres, even large AGVs can be fully safeguarded used only two Leuze RSL 400 scanners.

Models available with PROFIsafe/ PROFINET interfaces make it much easier to integrate the devices, particularly when many different protective field configurations are used.

Building Rolle village – one brick at a time

The team that was responsible for developing Shamila Trading Enterprise to attaining SABS product certification for SANS 1215 - concrete masonry units and SANS 1058 - concrete paving blocks.

BI leverages synergies across Hudaco Group in ongoing diversification strategy

Being part of the broader Hudaco Group allows Bearings International (BI) to leverage synergies across a broad range of companies, meaning it can offer a complete product basket at its extensive branch network countrywide.

In order to maximise this leverage across diverse industries, BI has successfully implemented a new Business Development Leader (BDL) management structure, with a dedicated and focused approach to core market segments.

These segments are Mining, Agriculture, Sugar, OEMs, Steel, FMCG, Automotive, Services and Infrastructure, Wholesale and Retail, and Cement, Pulp & Paper and Chemicals.

In addition to the BDL team, BI has appointed Victor Strobel as Offer Marketing Manager, reporting directly to BI Business Unit Head at the Parkhaven head office. Strobel has 33 years' industry experience, consisting of three years on plant, 15 years in sales management, and 15 years in marketing and product management. Strobel oversees the Product Management team, with the main goal of consolidating the marketing efforts into profitable growth.

"BI's unique approach is to target existing and potential customers at grassroots level. The sales force will therefore service the daily customer requirements. The BDL team, on the other hand, will look specifically to nurturing co-operative relationships with all relevant internal and external stakeholders," Strobel explains.

"BI is a house of world-class leading brands, and we are working closely with our suppliers and the larger Hudaco Group to penetrate new market segments and grow through innovative marketing initiatives." Apart from its extensive branch network in South Africa, BI is also focusing on unlocking opportunities elsewhere on the continent.
From bearings to variable speed drives (VSDs), motors, gearboxes, sprockets and chains, BI offers total solutions for a diverse range of customers, applications, and industries. Tier 1 automotive OEM applications, for example, are serviced from BI's warehouse in Parkhaven, which also features a bonded store facility.

An example of BI's diversification into ancillary products is adding electronic motor control solutions from Hudaco Group Company Varispeed to its extensive offering. Varispeed has just launched its VDrivePlus and AlphaDrive-Micro VSDs onto the market.

The AlphaDrive-Micro VSD from Varispeed is a compact frequency inverter ranging from 0.2 kW to 5.5 kW, and available in 240 V and 400 V. Together with the VDrivePlus, these VSDs offer the best performance-to-cost ratio on the market,

Victor Strobel
Offer Marketing Manager

without compromising on quality and reliability. *"Due to the current economic environment, the market is very price-sensitive. Therefore, any energy-efficiencies or cost-savings we are able to offer is hugely beneficial,"* Strobel notes.

Certified in accordance with the latest European standards and regulations, the Alpha Drive Micro and Micro Plus are ideally suited to most applications in the South African market, including mining, food and beverage, manufacturing, and agriculture.

The VDrivePlus from Varispeed is a much larger drive, ranging from 0.4 kW to 400 kW, available in 240 V and 400 V. This more advanced VSD features advanced motor control based on DSP technology, together with 'smart' auto-tuning. Additional features include flexible inverter control, dual high-resolution analogue inputs, and free mappable I/O channels.

Standing, from left to right:

- Surendran Naidoo; SABS; SMME development officer
- Solly Mhaule; DEDT; Deputy Director: Enterprise Development
- Shadow Nyathi; founder and CEO of Shamila Trading Enterprises
- Dumisani Mngadi; SABS; Head of SMME department
- Jeff Velelo; MEGA; Senior Manager: Funding

Shamila Trading Enterprises makes approximately 100,000 stock bricks per day. The company has recently upgraded its offices, including the development of a dedicated laboratory that allows them to test every batch of bricks. In order to maintain SABS certification, the company will need to document the results of each batch test and is subject to random audits and independent testing of bricks by SABS.

SAIEE Welcomes New IRP's Favourable Outlook on Renewable Energy and Storage in South Africa

The South African Institute of Electrical Engineers (SAIEE) has welcomed the new Integrated Resource Plan (IRP), and in particular, the energy master plan's positive attitude towards growing renewable energy and storage in South Africa. The government gazetted the 2019 IRP on Friday (October 18, 2019).

SAIEE CEO, Sicelo Xulu said that the new IRP was long overdue as the last one was published almost a decade ago in 2010. *"Since then several new technologies have been introduced, not to mention environmental developments, that require an updated plan that considers all the necessary factors towards achieving a sustainable energy future for South Africa,"* Xulu said.

The SAIEE believes that the integration and strengthening of renewable energy are vital towards energy planning in the country.

Last year, the SAIEE jointly hosted a session with Conference Internationale des Grandes Reseaux Electriques (CIGRE) at the University of the Witwatersrand (Wits), to discuss the integration of renewable energy into the grid, and the broader implications for energy planning. The session concluded that renewable energy should be pursued as part of a low-cost energy mix, considering balanced socio-economic impacts such as a just transition, guarantee a reliable and secure power supply system.

"Considering the declining costs of solar and wind generation, we are pleased to note the plan allows for a significant increase in the renewable energy mix, from 6% to above 25% by 2030. The SAIEE is also satisfied that the allowance for energy storage has been increased by 66% to 5000MW as we requested," Xulu said. It is also good to see the accommodation of these new resources on a distributed or 'small scale embedded generation' basis, in a way that will unlock new opportunities within the municipal distribution industry.

"This will assist in limiting renewable energy curtailment and technical losses while managing the increased variability in the grid. Alternative energy storages cost, such as batteries are also declining and making their business case easier," Xulu added.

He said that the SAIEE is confident that its other recommendations to the Department of Mineral Resources and Energy (DMRE) will also be considered favourably. SAIEE's proposal includes moving towards a publicly available open-source IT platform for housing the energy model, instituting a scientific approach to decommissioning of assets, and commissioning a study to determine the technically responsible limit for renewables, before implementation by the department of minerals and energy.

"We affirm our support towards a safe, green and lower-cost mix of energy technologies. However, we want to caution that the primary purpose of a grid, which is to provide safe and reliable access to energy supply, must be maintained through careful engineering studies," Xulu said.

As part of the SAIEE's commitment to South Africa's energy future, the Institute will be hosting its inaugural SAIEE National Conference from 27 – 29 November in Johannesburg. The Conference is looking ahead at how we can "Engineer an Africa for the Future". We are bringing together local and international thought-leaders to brainstorm on critical issues that impact the continent. This includes building a sustainable energy future using a mix of technologies, including existing fossil-fuelled plant, gas, renewable energy and storage, nuclear, all in conjunction with the impact of the Fourth Industrial Revolution.

"One of the biggest challenges that our industry faces is the realignment and restructuring of the Electricity Supply Industry. This includes scaling up of all alternative energy sources, renewable, gas, hydro and nuclear energy generation in Africa. The question of a sustainable energy future is more imperative than ever as we navigate the economic and environmental challenges that lie ahead," Xulu said.

The Conference will include a keynote address by Public Enterprises Minister, Pravin Gordhan, including a solutions-driven panel discussion on South Africa's power crisis led by award-winning business journalist, Bruce Whitfield. The SAIEE will also be launching its Nuclear and Women in Engineering Chapters at the Conference.

More information about the SAIEE National Conference, including the draft programme and registration, is available at www.saiee-conference.co.za.

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SAIEE NATIONAL CONFERENCE 2019

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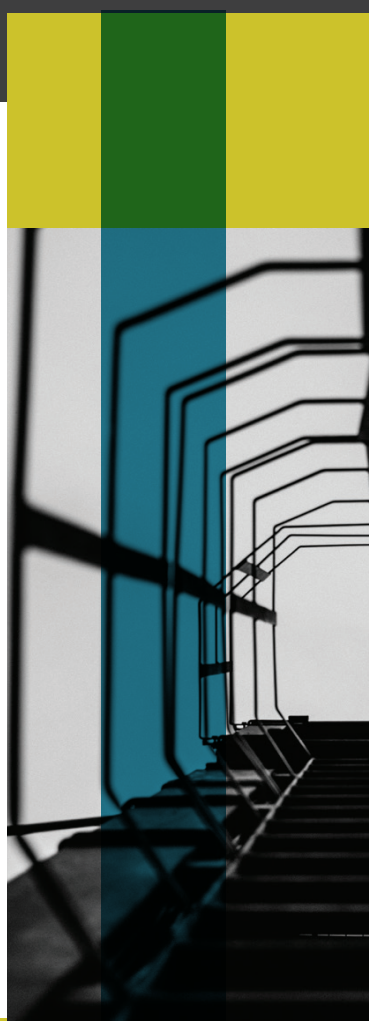
South African Institute of Electrical Engineers (SAIEE) are hosting the **1st SAIEE National Conference 2019** as a **future-thinking gathering** of the electrical and electronic engineering fraternity with a vision of **Engineering an Africa for the Future.** The Conference will **facilitate future-thinking engagement** on the latest technology and trends, innovation, challenges facing the sector, policy, skills development and social enterprises. It's about driving meaningful change from a sector that has the influence to make a difference.



PROGRAMME OVERVIEW

The programme is track driven and focuses on the following themes:

TRACK 1: BUILD
Building a Smart Future

TRACK 2: POWER-UP
Powering a Future Africa

TRACK 3: AUTOMATE
Driving a Future Africa through Automation

TRACK 4: CONNECT
Technology and Connectivity for a Future Africa

TRACK 5: EMPOWER
Capacity Development for a Future Africa

TRACK 6: CHANGE
Celebrating Africa's Change Makers

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De Beers, Debswana give insight into digital transformation

Leading mining companies Debswana and De Beers gave key presentations about how they are implementing digital transformation in their operations at the 5th Annual Natural Resources Forum, hosted by French software leader Dassault Systèmes.

Accessing data from over 1 km underground is a particular challenge for the Debswana Diamond Company of Botswana, according to Brian Chimoba, Principal – Business Process Integration. Here the diamond-mining giant is leveraging the 3DEXPERIENCE® platform, Dassault Systèmes's flagship digital platform, to optimise its geoscience, mining, and production operations.

De Beers was represented by Giel Marais, Senior Automation and Information Manager, and Freddie Breed, Senior Mining Engineer. They gave a joint presentation on how the Venetia Underground Project is aiming to develop an integrated management solution for the entire operation.

Both companies are evidence of a new mindset in the South African mining industry, according to David Osborn, Managing Director of Dassault Systèmes in South Africa. While the local mining industry remains a tough environment due to a combination of political, economic, and social factors, a key realisation is that change is inevitable.

"Now that we have all of the challenges mapped out, mining companies are acknowledging that, if they continue with business as normal, results will not improve. It has got to take a different approach to doing things. Due to the fact that the mining industry has been stagnant for so long, it has since been surpassed in the technology stakes by other industries such as manufacturing, automotive, aerospace, and oil and gas. It has the opportunity to cherry-pick what will work best for it in terms of digital innovation," Osborn argued.

Mining companies like Debswana and De Beers have intuited the significant value inherent in such an approach. *"The key is collaboration. We might not have all of the solutions at hand, but together with our partners, we can solve their problems. Helping establish a future-proofed mining industry based on digital innovation is our main goal,"* Osborn affirmed.

Raoul Jacquand, CEO of the GEOVIA Brand from Dassault Systèmes, stressed that the positive experience of mining companies like De Beers and Debswana was creating a snowball effect within the local mining industry. *"Hearing what our clients have to say about their experiences in implementing our solutions, and how they are collaborating with us, is so much more powerful."*

A Microsoft Hololens mixed reality smartglass presentation.

It is for this reason that Dassault Systèmes established the Natural Resources Forum as an interface with the local mining industry. *"We also realised that, in the conventional way of doing things, the mining industry was jumping too quickly to the 'how'. They were more interested in the functionality and features required to solve specific technical problems, for example, as opposed to stepping back, take time to revisit the "why?" and the "what?" to ultimately serve a business purpose.*

"The main aim of the Natural Resources Forum is therefore to allow clients to understand our role as a business partner interested in the overall outcome. Of course, resolving all of the technical issues is still paramount, but we can get so much more out of a holistic approach. This has been a mindset change as much for us as for our clients, and it is an evolutionary process documented by the Natural Resources Forum over the years," Jacquand highlighted.

The forum has also been key to showcase the user-friendliness and flexibility of the 3DEXPERIENCE® platform, which is completely scalable according to specific client requirements and operations. *"The fact is that any mining company wishing to embark upon the digital transformation journey can start off small. We want to dispel the notion that it is overwhelming, complicated, and costly. There are tangible low-hanging fruit like simple enterprise collaboration that can deliver immediate results."*

The secret to the ultimate success of embracing digital transformation in the mining industry is maximising the potential of big data. *"Traditionally information has been synonymous with a mining company's competitive edge, but the digital platform reveals that democratising data unlocks its value so much faster. It allows mining companies to address an entire spectrum of issues on a single level, which means that a unified solution is entirely feasible,"* Jacquand pointed out.

However, he stressed that the 3DEXPERIENCE® platform was much more of an enabler than a replacement for any existing or competing systems. *"Not only is it completely scalable, ultimately it is a vehicle for innovation. As a result, it needs to be open by nature, and able to interact with the landscape of existing systems. It is there to give a direction for the future and assist mining companies in orientating their business strategies. Hence the platform's representative icon is a navigation compass, as it reduces complexity and guides businesses in the right direction towards clearly-defined goals."*

This is where the 3DEXPERIENCE® Twin of the Mine concept plays such a crucial role. A holistic virtual twin of a mining site can optimise operations through simulation. Exploring different scenarios in a virtual space will allow mining companies to simulate for any eventuality and plan accordingly.

This virtual twin is a powerful instrument to engage all stakeholders. *"What digital transformation achieves is to break down physical and organisation boundaries, which is essential for innovation. The fact that the mining industry is highly technical has resulted in a series of silos developing over time.*

"Our 3DEXPERIENCE® solution brings all of these vertical silos together on a lateral level to leverage change and achieve a complete mining value chain. While automation in the mining industry has always thought to be synonymous with job losses, different opportunities will instead be presented, and current roles transformed rather than replaced," Jacquand concluded. wn

WEG's New 11 KV Variable Speed Drives on Ghana Mine

Two units of the newly developed WEG 11 kV Variable Speed Drive (VSD) have been commissioned in West Africa by WEG Automation Africa, a member of the Zest WEG Group.

According to Kirk Moss, senior manager: projects and engineering at WEG Automation Africa, the new WEG MVW3000 VSD is a valuable addition to its Medium Voltage (MV) VSD portfolio. The first two 11 kV units produced are for 850 kW ventilation fan motors in an underground gold mine in Ghana.

"In line with WEG's ongoing innovation, the addition of the WEG MVW3000 system brings a range of benefits to customers," says Moss. *"It gives WEG Automation Africa even greater flexibility in our market offering, further enhancing our capability to provide customised solutions."*

The design is based on the well-known cascaded H-bridge (CHB) topology, using multiple low voltage power cells in combination to achieve the desired voltage output. The input switch, phase-shifting transformer and VSD are fully integrated in a single MV panel.

"The WEG MVW3000 is particularly suited to applications where there are standard motors with no special insulation," he says, *"or where existing motors are being modified for VSD control."*

This VSD delivers high quality input power using low harmonic multi-pulse transformers. Users benefit from a high efficiency of over 96.5% throughout the entire load range, and a power factor of more than 0.95 throughout the entire speed range.

"The design includes power cells with long-life plastic capacitors, which are more reliable and last longer than dry type capacitors," he says. *"They also have the advantage of not needing to be reformed after long periods of storage."*

In standard configuration, the 11 kV VSD is available from 40 A to 400 A – or 640 kW to 6500 kW – although larger sizes are also available if required.

Among the options on the WEG MVW3000 is an automatic cell bypass solution. This ensures minimal reduction in the output-rated torque so that normal operations can continue. Redundant power cells can also be added to the design to ensure that 100% torque can be maintained. Prior to delivery, all VSDs are fully load-tested in WEG's state-of-the-art facility in Brazil. wn

The latest addition to WEG's range of MV VSDs is the 11 kV MVW3000 solution.

The WEG MVW3000 VSD was tested extensively at WEG's state-of-the art testing facility in Brazil.

The WEG MVW3000 VSD installed underground at a gold mine in Ghana.

The title of my Presidential Address was Mining Engineering, a Discipline for the Future. The focus was mainly on South African-based operations, deep gold mining, and other underground mining.

Twenty-three years later, I shift that attention onto a broader scale. What is the current real driver behind mining engineering? The focus needs to be on world minerals demand and for the medium term at least. Even after netting off possible reductions in demand due to more responsible and efficient future behaviour patterns, and also reductions due to development of suitable substitutes, the demand for minerals is likely to far outstrip foreseeable resources, mining projects, and mining operations.

BY | DON ROSS-WATT | SAIMM PRESIDENT: 1995–1996

The boundaries will be significantly stretched for the location and characteristics of prospective mineral deposits, for the technologies required in identifying and exploiting mineral deposits, for the achievement of safety excellence, for the achievement of excellence in environmental interaction, and the achievement of excellence in social interaction.

Competent mining professionals will be required, and in adequate numbers, including geologists and resource evaluators, mining engineers, and virtually all engineering disciplines, and the metallurgical processing disciplines, also professionals in Earth sciences and social practitioners. Much input is required in conceptualising, identifying, evaluating, developing, and exploiting sufficient viable

Mining engineering
- some perspectives on managing risk

Mineral resource deposits are what they are, and each brings its particular challenges to the table.

minerals production capacity. Up to my presidential year, I had been involved in deep gold mining and underground base metals mining, with some limited international exposure. Since then, I was involved in surface and underground mining for a range of technologies and mineral products, in project development, in new business opportunities and also gained much more extensive international exposure. I want to share a few thoughts on the risks and constraints of developing increased minerals production capacity, some obvious, all undoubtedly pertinent.

Well recognised risks include that the resource may not be of the size and quality evaluated, capital blowout in cost and time, inability to meet the anticipated mining selectivity and unit cost, inability to achieve the anticipated processing recovery, quality, and unit cost, and inability to achieve the anticipated revenue stream, as well as the range of infrastructure, safety, environmental, and social risks. Now let's move on from here.

'Unidentified or unforeseen issues' may constitute a severe risk to viability, or safety, or the environment, or social interaction, or may even become a fatal flaw. It is necessary

Mining Engineering

continues from page 27

to diligently and exhaustively review and attempt to identify all such possibilities upfront using whatever specialist input and broad experience are available. 'What could occur?' Even then you will invariably miss something, so recognise this risk in your planning. A most daunting task, and so often neglected. *(While this note addresses the risk, the 'upside or blue sky dimension' may equally occur in significant steps rather than incremental opportunities. The ability to recognise both is a recipe for success.)*

Digital modelling is an indispensable tool in evaluation, mining, processing and throughout the operation. It is also used to assess risk and impacts. Serious risks, however, tend to occur in significant step changes rather than incrementally and must be considered in terms of scenarios and not merely in terms of sensitivity distributions. Scenarios need to include extreme cases. For example a prolonged period of drought immediately before process start-up, a prolonged period of excessive rain for a flood-sensitive project, a significant change in employment or social or political relations, or the impacts of a seismic event on a waste or tailings storage facility. And so many other circumstances.

Significant positive breakthroughs in mining and processing will be required if production is to come anywhere close to meeting world minerals demand. Consider for example earlier developments of heap leaching of gold from very low-grade weathered resources, the solvent extraction/electrowinning process (SX/EW) enabling scavenging of copper from very low-grade resources and marginal waste materials. Added to that, the massive scale-up in surface mining equipment size and significant advances in equipment control and monitoring, significant advances in exploration tools, progressive improvements in underground mechanisation, monitoring and communication, ongoing improvements in accuracy and efficiency of mining methods, and significant digital contributions all round. What lies ahead?

Feasibility studies may, and very often do, turn out to be some long-distance from reality for a variety of reasons, including significant unidentified or unforeseen issues. This must be recognised. Planning and operations need to be sufficiently robust to cope. Capital cost and capital schedule overruns are again likely to involve significant step changes rather than incremental impacts. So it is necessary to run some extreme scenarios to assess the extent of any possible embarrassment and the necessary remedial action.

Risk consists of the probability of occurrence and the consequences of occurrence. The probability of occurrence is the minor issue; what is essential are the consequences. Consequences require exhaustive evaluation no matter how remote the chances are of actually happening. Consider, for instance, a most unlikely tailings wall overtopping or failure that takes place with devastating consequences. Consider backfilling a vast void in the upper levels of an operating mine.

Despite whatever controls are put in place, the consequence of failure would be devastating. Consequence identification and management is the name of the game. Environmental requirements have become truly internationalised and are equally challenging wherever your operation. *(In the United States, I understand new mining operations are effectively not permit-able. Now many other countries come close.)* Cyanide is always an emotive issue. The impacts, however, of acid mine water-drainage via mining and processing operations; or waste rock and tailings storage are difficult to control, are becoming just as emotive, and involve a much more extended period of impact. *(Interestingly certain environmental contaminant constraints are now approaching levels so low that reliable measurement itself becomes painful.)* Well-established industry information describes the risks and requirements that may be encountered. But always consider carefully what you may have missed, it is almost inevitable that you will walk past something.

Consider the often quoted 'in-perpetuity commitments' regarding contamination mitigation or other protection requirements which may be contained in an operation's closure documents. What does this mean, 10 years, 20 years, or literally in perpetuity? How can this be achieved? This needs to be carefully considered and defined and documented and understood.

While formal environmental permitting requirements may be precise, the importance of 'informal social permitting' is not always fully recognised and is at least as critical to operation. The ability to achieve the latter may be project-defining or even project-excluding. This requires extensive work on the ground in consultation with local communities, rather than with higher authority. *(You first need to walk the walk and talk the talk in the hills.)* Social permitting commitments may be challenging, for instance, when considering large-scale relocations, or in addressing extensive informal mining, or in water management commitments. Be

aware that minor issues can trigger a severe social confrontation.

Consider communities becoming wiser to relocation 'opportunities' - the second time around may be exclusionary. Consider informal miners being paid elevated prices for gold as part of underworld money laundering. Consider also the responsibility for the safety of informal mining operations on the property. Stability of underground rat-holes or people swarming over surface blasted rock.

A further example was the requirement that more than 75% of the capital contractors and operating employees of a project had to be drawn from local communities, (where hardly anyone even owned a motor vehicle). The probability of occurrence is a minor issue. What is essential are the consequences. Consequences require exhaustive evaluation of risk, no matter how remote the chances are of it happening. Consider, for instance, a most unlikely tailings-wall overtopping or failure that takes place with devastating consequences. Consider backfilling a massive void in the upper levels of an operating mine. Despite whatever controls are put in place, the consequence of failure would be devastating. Consequence identification and management is the name of the game.

Environmental requirements have become truly internationalised and are equally challenging wherever your operation. (In the United States, I understand new mining operations are effectively not permit-able. Now many other countries come close.) Cyanide is always an emotive issue. The impacts of acid mine water drainage via mining and processing operations are challenging to control. This will become just as emotive, and involve over a more extended period of impact. *(Interestingly certain environmental contaminant constraints are now approaching levels so low that reliable measurement itself becomes painful.)* Well-established industry information describes the risks and requirements that may be encountered. But always consider carefully what you may have missed, it is almost inevitable that you will walk past something.

Consider the often quoted 'in-perpetuity commitments' regarding contamination mitigation or other protection requirements which may be contained in an operation's equipment. So instead of maybe five significant contractors on-site, besides, 30 or 40 smaller contractors had to be managed. Mining equipment and process operators had to be sourced from local villages, and extensive training had to be implemented. Eventually, it all worked.

There are any number of site-specific issues that must be tied down *(formally)* through (informal) social permitting, and with no short cuts.

Water supply is a multi-faceted risk facing most projects, and often a nightmare, sometimes sinking an otherwise 'viable' project. Overall, water demand is increasing, and supply, or access to supply, is more than likely to decrease in the future.

Provision of water is often 'the most important issue'. The massive water processing and delivery infrastructure provided for some large high-value projects *(which can afford it)*, makes for sobering and enlightening reading. Also, consider the importance of extracting the maximum amount of water from process tailings. The seasonal impacts on water supply for a smaller project may be highly significant. Caution is required when dealing with more complex water rights agreements. Excess water, surface or underground, can also be project-defining.

Any impact on local/traditional water supplies is an incredibly emotive issue in most project developments. *(Don't mess around with anyone's streams.)* An example was a massive project involving impact on streams supplying the town and local villages. Appropriate and permit-able reservoirs were included in the planning. However, public opinion was strongly negative, resulting in lengthy periods of resistance and even substantial violence. The project was cancelled, and the town was left to ruefully contemplate the lost opportunity for employment to the local economy.

Then there is pollution through discharge or seepage. Such pollution is supposed to be a well-understood risk, but the devil is in the detail. Contain or treat and discharge? Specialist input and broad experience are required. This may involve a very high cost and long-term commitment. This can be project-defining or even a fatal flaw and certainly can lead to severe social confrontation. Environmental constraints to contaminant levels will inevitably tighten over time and must not be underestimated.

Characterisation of waste rock *(and any other potential construction material)* may be somewhat overlooked. It needs to be very thorough, including an adequate drilling programme. Wall stability and contamination issues are better established. Waste rock as a first construction component or for longer-term construction requirements of the ongoing operation can be critical.

Mining Engineering

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Characteristics of the surrounding host rock, as well as the water table and the local topography, need to be very well understood. There is potential for a fatal flaw. Such an example was an extensive network of complex more delicate karst structures quite capable of transporting contamination for kilometres, and which then reappears somewhere as surface seepage. *(Even seepage equivalent to the flow of a garden hose would be entirely unacceptable.)* The role of project elevation of the water table, in this case, was decisive. The potential social impact could have been massive. The issue became project defining and without very high-cost ongoing mitigation measures involving a thick lining of compacted material to the tailings storage facility, may well have become a fatal flaw in the project.

Space for accommodating waste rock and tailings storage may be constrained to a lesser or greater degree. This can, in more extreme cases, limits the total exploitation of mineable ore and the life of the operation. For example, an operation of a tailings dam capacity, limited ore available for extraction. To extract only the more payable ore, the life of mine planning, cut-off grades, and process optimisation had to be altered. Waste rock storage constraints followed those of the tailings storage closely.

Mining companies, especially in South Africa, have scaled-down on in-house technical expertise. The use of external consultants on a full scale is now an inescapable part of the industry and works well.

We must recognise that specialist-consultants (world-class), may be required in certain circumstances. An example is a review board, representing the appropriate disciplines, regularly interacting over a long period for the construction of a large tailings storage facility. This is also in association with a specialist groundwater consultant to ensure continuity of community springs and water supply from streams. Also, in this case, a specialist consultant (from Belgrade) on karstic structures. *(Karstic systems are massive in the Balkan countries).* Such review boards may be essential, *(but must also be recognised as not infallible).* Specialist consultants in environmental and social issues were also on board, making vital contributions. We learn time and time again, that if in doubt, consult an appropriate specialist right away.

Instances of non-standard capital construction and non-standard operating procedures are genuine. Adequate controls need to be in place. However, provision for such instances happening must be made through design, construction and operations, and in contingency planning. Examples include significant seepage from even a small defect on a tailings dam, loss of viability due to deviations in selective mining, the severe risk to the underground workings arising from deviations in backfill material preparation, inappropriate robbing or poorly planned pillar stability, and inadequate rock-breaking discipline. Any discontinuity between process plant backfill production and mine backfill placement creates a significant area of risk as several severe examples have shown.

Responsible mining requires benchmarking and then some. This can only be achieved through studying the latest literature, attending professional conferences, engaging appropriate consultants, having direct communication with operators to gain on-the-ground information. You must identify both the best and the most unsafe practices to see your planned operation in perspective. If your planning is outside of the norms, question it, is this due to improvements or due to shortfalls.

The SAIMM and similar professional bodies certainly play a robust benchmarking role. It is always necessary to find a functional balance between extreme conservatism on the one hand and an operation that may be considered aggressive or even vulnerable on the other.

I suggest that it is necessary to define contingency planning for a range of scenarios, including extreme examples, at an early stage of the planning process. Once construction and operations commence and are ongoing, you will quickly move from planning to reality, maybe some way apart. *(You can't then afford to be caught with your pants down when circumstances/ opportunities change.)*

Always try to identify and define the 'key issues' for the particular project? Very often we don't get this right.

So there it is - my few thoughts on risks relating to a minerals demand-driven, and potentially development intensive industry. Now, twenty-three years later, the industry will demand more well-qualified and diligent professionals capable of clear and incisive thinking, and with the ability to put this thinking into practice. wn

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Geochemical mapping of drill core samples

A LIBS-XRF drill core scanner prototype was developed through a collaboration between Avaatech B.V. and SPECTRAL Industries BV. This core scanner was tested on a drill core sample of a polymetallic sulphide ore originating from the historic Reiche Zeche mine in Freiberg, Germany. Comparing the LIBS and XRF data showed that both techniques produce similar results for all the significant elements of which the sample is composed. We observed the differences between the results of LIBS and XRF, which attributed to differences in the size of the measured surface area, signal to noise ratio, and detection limits of LIBS and XRF. Additionally, XRF cannot be used to detect light elements such as oxygen or carbon, while these elements can be identified with LIBS. Another advantage of the LIBS technique is that the data acquisition speed is much higher. This is especially useful when drill core scanning is applied in large mineral exploration projects in which hundreds of kilometres of drill core samples are produced. Drill core sections that are of particular interest can be further investigated using XRF, which may provide a higher precision for determining the content of certain trace elements such as arsenic.

BY | MARINUS DALM

Core drilling is often used in the exploration for mineral resources and other geological studies to obtain information about the Earth's subsurface.

Analysis of the obtained drill core samples is traditionally performed through visual inspection and laboratory analyses, which are generally time consuming and expensive.

Alternatively, sensors can be used to collect mineralogical and geochemical data at much higher speeds and lower costs.

Drill core scanners are systems that use a specific sensor or combination of sensors to gather information on drill core samples. Sensor techniques that are commonly used for drill core scanning are digital imaging and near-infrared (NIR) and short-wavelength infrared (SWIR) hyperspectral imaging. These techniques provide information on a material's visible properties and the occurrence of specific minerals (Thompson et al., 1999; Dalm et al., 2018). However, ore minerals can often not be detected, and no information is provided on the chemical composition of samples. This while the concentration of ore minerals in the rock is usually the most critical parameter in mineral exploration studies.

Laser-induced breakdown spectroscopy (LIBS) is a sensor technology that provides information on a material's chemical composition. It utilizes a pulsed laser beam to ablate a small amount of material on the surface of a sample and break it down into a plasma consisting of atoms, ions and free

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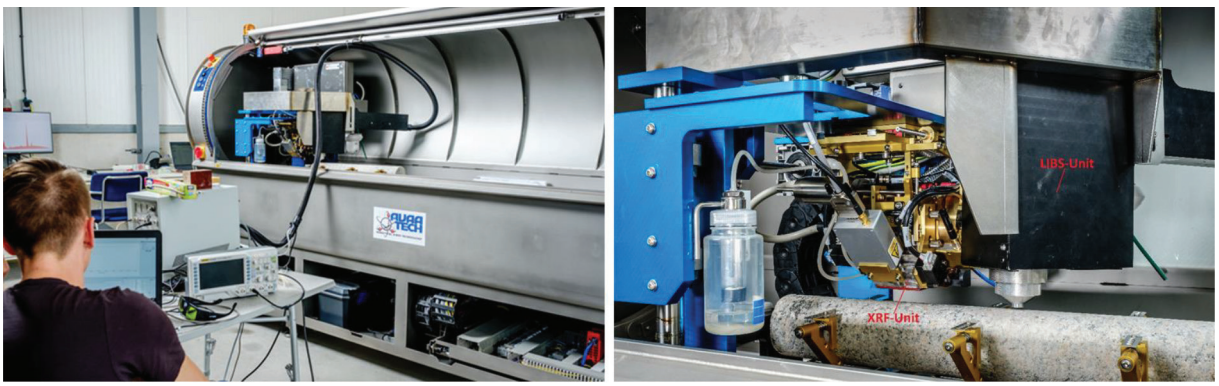

Figure 1: LIBS-XRF core scanner prototype

electrons. When the plasma cools down, it emits electromagnetic radiation because the free electrons release energy in the form of photons when they fall back into atomic or ionic orbits (Radziemski & Cremers, 2006).

The wavelength the emissions produce depends on the specific atom or ion in which the electron is captured. The intensity of the discharge is related to the concentration of that atom or ion. The composition of a material can, therefore, be determined by using a spectrometer to measure the radiation that is emitted by the laser-induced plasma.

X-ray fluorescence (XRF) is another technique that can be used to determine chemical composition. No plasma is produced with XRF, but electrons in the inner orbitals of atoms are ejected from their orbit by bombarding them with high energy X-rays. Electrons in higher orbitals will subsequently fall into the hole that is left behind and release energy in the form of photons (Beckhoff et al., 2007). As with LIBS, the intensity and wavelength position of the photon emissions depend on the type of atom and its concentration in the sample. The composition of the sample can, therefore, be determined by measuring these emissions with a spectrometer.

One of the main differences between LIBS and XRF is that LIBS deals with emissions of the outer-shell electrons, while XRF deals with emissions of inner-shell electrons. For certain transition metals, many different energy levels exist in the outer-shells on which electrons can be captured. When these transition metals occur in relatively high concentrations, their emissions may dominate the LIBS spectrum and occlude emission lines of other elements. The XRF technique does not suffer from this phenomenon because a lower number of inner-shell energy levels exist.

The disadvantage of the XRF technique, however, is that light elements are more difficult to detect because the inner-shell energy levels of these elements are relatively low and have a low penetrating power (Beckhoff et al., 2007). As a result, the emissions from light elements are more quickly absorbed by the surrounding air. This problem can be partly overcome by measuring in an environment where the air is replaced by helium or argon. However, detecting elements lighter than sodium also requires a unique configuration of the XRF sensor (Beckhoff et al., 2007). Hydrogen, helium and lithium cannot be detected with XRF at all.

A comparison was made between LIBS and XRF to investigate if a combination of both techniques offers unique opportunities for fast drill core scanning in the field. This comparison is based on a test with the LIBS-XRF core scanner prototype.

Figure 1 shows a photo of the LIBS-XRF core scanner prototype that was tested in this study. This prototype was developed by integrating the LIBS instrument of SPECTRAL Industries into Avaatech's 4th generation XRF core scanner. Table 1 presents the specifications of the core scanner and the LIBS and XRF instruments.

The LIBS-XRF core scanner prototype was tested on a 30 cm long drill core sample of a polymetallic sulphide ore originating from the historic Reiche Zeche mine in Freiberg, Germany. Around 800 years ago this ore was mined as a resource for zinc, lead, copper, and silver. The metal is mainly composed of the minerals pyrite, sphalerite,

Core scanning system	
Dimensions	2953 x 925 x 1775 mm (L x W x H)
Weight	1450 Kg
Sample dimensions	
Core length	300 - 1600 mm
Core width	40 - 140 mm
XRF instrument	
X-ray tube	
Voltage range	4 - 50 KV
Current range	0 - 2 mA
Anode type	Rhodium
Tube-sample filters	Al, Pd and Cu
Tube lifetime	5000 - 8000 hours
X-ray detector	
Type	SGX Silicon drift detector
Resolution	133 eV at 5.9 KeV
Detectable element range	Mg - U
Slit system	
Downcore resolution	0.1 - 10 mm
Crosscore resolution	2 - 12 mm
LIBS instrument	
Laser	
Type	Litron Nano SG 150-10
Wavelength	1064 nm
Pulse length	4 - 6 ns
Max pulse energy	150 mJ
Max repetition rate	10 Hz
Spot size	100 µm
Spectrometer	
Type	SPECTRAL Industries IRIS echelle spectrometer
Detector	Deep-UV sensitive CMOS
Spectral range	180 - 800 nm

Table 1

galena, chalcopyrite and arsenopyrite. Gangue minerals include calcite, siderite, and quartz (Bayer, 1999).

The LIBS and XRF measurements were acquired along the same line in the downhole direction of the sample. The surface area on which the XRF measurements are performed can be adjusted by changing the slit size of the instrument. The slit size was set to 0.2 mm downhole and 2 mm cross core for the test measurements. The spatial resolution of the XRF measurements was set at 0.2 mm. The range of elements that can be detected with XRF depends on the excitation energy that is used, which relates to the voltage that is applied to the X-ray tube. The XRF data was acquired by making one scan while operating the X-ray tube at 10 KV and one scan while operating at 30 KV. For each XRF spectrum, an integration time of ten seconds was used. The total time needed to acquire the XRF data was ten and a half hours.

The surface area on which the LIBS measurements were performed was around 0.1 mm in diameter, and the spatial resolution of the measurements was 0.12 mm. The LIBS measurements were gated using a delay of 2.4 µs between plasma generation and data acquisition. LIBS spectra were acquired at 10 Hz using an integration time of 98 µs. The laser power was set at 15 mJ per pulse. The total time needed to learn the LIBS data was three minutes and twenty seconds. LIBS measurements were performed while flushing the instrument with argon to obtain representative data on elements occurring in the atmosphere, such as oxygen and carbon.

Processing of the LIBS and XRF spectra was performed by first subtracting the baseline from the spectra. Subsequently, characteristic atomic emission lines were identified, and a Voigt or Gaussian was fitted to the peaks in the LIBS and XRF spectra respectively. The line intensity of the elements was determined by calculating the area of the Voigt or Gaussian profile.

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RESULTS

Figure 2 presents the line intensities of selected element peaks in the measured LIBS and XRF spectra versus the position of the measurement. Element line intensities shown in black are based on the LIBS data and those shown in blue are based on the XRF data. Figure 2 also shows a photograph of the sample. The red rectangle on this photo indicates the line along which the LIBS and XRF spectra were measured.

All the element line intensities shown in Figure 2 are scaled to the same range, and absolute magnitudes between elements can be different. The relationship between measured line intensity and actual element concentration is unknown for both LIBS and XRF and may be non-linear. Both techniques are subject to chemical matrix effects, which is the phenomenon in which the other constituents of the sample influence the line intensity of an element. Additionally, line intensities may depend on physical matrix effects such as the surface roughness, hardness, density, grain size, or crystallinity of the material that is measured (Harmon et al., 2013; Potts & West, 2008). The influence of chemical and physical matrix effects in LIBS may be different than those in XRF.

Figure 2 shows that the LIBS data appear noisier than that of XRF. This is partly caused by instrumental noise because LIBS is subject to signal intensity fluctuations resulting from an uneven energy distribution between laser pulses and physical matrix effects (Harmon et al., 2013). However, most of the noisy appearance is likely due to the relatively small surface area that is measured with LIBS in combination with the occurrence of fine-grained minerals in the sample. This means that small-scale heterogeneity of the drill core sample itself is the main reason for the noisy appearance of the LIBS data. The influence of small-scale heterogeneity on the XRF data is lower because the surface area that is measured with XRF is larger. Compositional variations due to the occurrence of fine-grained minerals in between minerals with a larger grain size are therefore averaged out.

Figure 2 does not present any LIBS data for arsenic and XRF data for oxygen and carbon. This is because oxygen and carbon are light elements that cannot be detected with XRF and arsenic emissions were not observed in the LIBS spectra. For the elements that were identified with both LIBS and XRF, the measured line intensities presented in Figure 2 show a similar trend. However, differences between the results of LIBS and XRF can also be observed. Most of these are likely caused by differences in the surface area that is measured. Especially the field of view of the XRF instrument in the cross core direction is much larger than that of the LIBS instrument (2 vs 0.1 mm).

The most dominant mineralogical feature that can be observed from the data presented in Figure 2 is the occurrence of the white veins that can be seen in the photograph. The positions of two of these veins are highlighted in pink. The LIBS data shows that the white veins can be identified by using the line intensity of oxygen. This can be explained by the fact that the white veins are mainly composed of quartz (SiO_2) and/or calcite ($CaCO_3$), while most other minerals that occur in the sample are sulphides (pyrite (FeS_2), sphalerite (ZnS), chalcopyrite ($CuFeS_2$), galena (PbS)). Based on the line intensities of Si and Ca, it can also be derived that the highlighted vein on the left mainly consists of calcite, while the one on the right consists mostly of quartz. The source of carbon in the quartz veins is somewhat unclear but might result from minor occurrences of other carbonates or small fluid inclusions containing CO_2. Fluid inclusions in quartz are typical in the type of deposit from which the drill core sample originates.

The second mineralogical feature that can be seen in Figure 2 is the occurrence of pyrite (FeS_2) versus sphalerite (ZnS) and chalcopyrite ($CuFeS_2$). In the left half of the sample, pyrite is the most abundant mineral, and occurrences of sphalerite and chalcopyrite can be identified from an increase in the line intensity of zinc or copper and a decrease in the concentration of iron. Occurrences of sphalerite and chalcopyrite seem to be spatially associated with each other since the line intensities of zinc and copper show similar trends. In the right half of the sample, sphalerite is more abundant, and the line intensity of iron is lower than in the left half of the sample. The iron in this part of the sample is probably contained by chalcopyrite, although sphalerite can also contain iron (Awadh, 2009). It is also possible that relatively small pyrite grains occur in between those of sphalerite and chalcopyrite and that the measured iron is from a mixture of several minerals. This cannot be confirmed with either LIBS or XRF since measured line intensities may not be linearly related to element concentrations. A different analytical method is therefore required to verify the source of the iron.

The third mineralogical feature that can be seen in Figure 2 is the occasional occurrence of galena (PbS) and arsenopyrite (FeAsS). Galena can be identified from the relatively

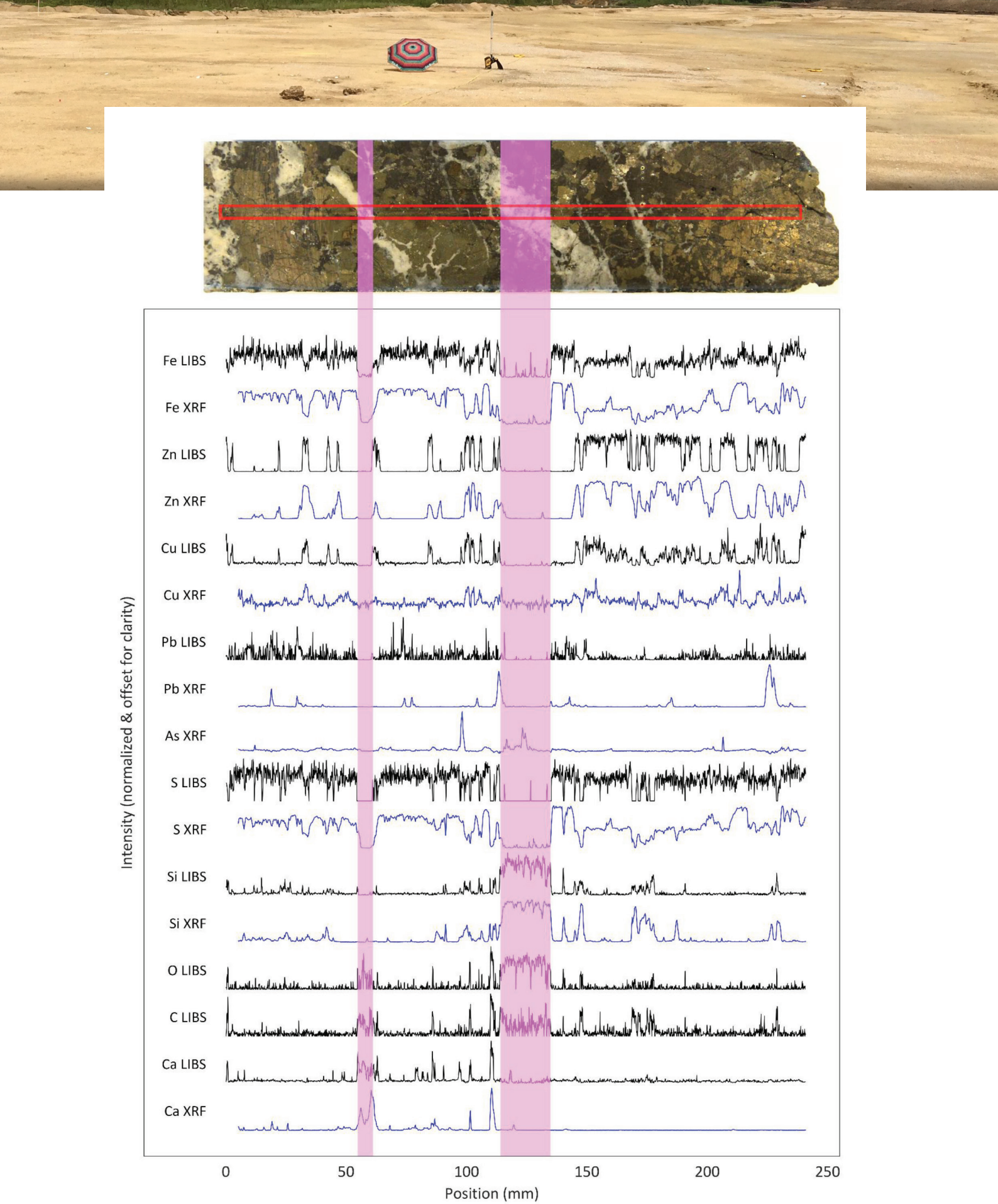

Figure 2: LIBS and XRF results of scanning a polymetallic sulphide ore sample. The pink bands indicate the position of quartz/calcite veins.

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high line intensity of lead and arsenopyrite from that of arsenic. Figure 2 shows significant differences between the results of LIBS and XRF for lead. A possible explanation for this is that the grain size of galena is relatively small. This is indicated by the fact that high line intensities for lead in the LIBS data occur over narrow ranges. Furthermore, the XRF data often still shows a small increase in the line intensity of lead at positions where the LIBS intensity of lead is high. When relatively small galena grains occur at the spots where a high intensity for lead is measured with LIBS, these will be averaged out in the XRF measurements because the surface area that was measured with XRF is larger.

Differences in the measured surface area can also create situations in which galena grains occur within the area measured with XRF, but not within the area measured with LIBS. This explains why the XRF results can show high line intensities for lead while LIBS does not. The same could apply to the arsenopyrite, which explains the absence of emission lines of arsenic in the LIBS data. However, it is also possible that the concentration of arsenic is below the detection limit for LIBS. The detection limit varies between elements and detection limits in LIBS are often different than those in XRF.

Finally, it was mentioned that the ore deposit from which the drill core sample originates was historically also mined for silver. With the XRF instrument, silver could not be measured because the used slit contains silver, which interferes with the detected line intensities for this element. From the LIBS data, no emission lines of silver were observed, but many of these lines also overlap with those of iron. It is also possible that the drill core sample used in the test was taken from a part of the deposit in which no significant amounts of silver occur.

DISCUSSION

The core scanning system used in this study was based on Avaatech's 4th generation XRF core scanner on which the LIBS instrument developed by SPECTRAL Industries was integrated. XRF is a well-established analytical technique with applications in many different fields. It is often used for quantitative analyses, which is possible through calibration of the instrument with calibration standards. The same approach can be used to calibrate LIBS instruments. It is, therefore, likely to calibrate the LIBS-XRF core scanner to extract full quantitative information from each measurement instead of the semi-quantitative results displayed in Figure 2.

However, this does require a relatively broad range of calibration standards that represents the mineralogical variability of the deposit to account for the matrix effects that may be associated with LIBS and XRF. Extracting quantitative compositional information from individual LIBS or XRF measurements might not be needed for drill core scanning applications. The results in this paper showed that mineral occurrences could be inferred from the LIBS or XRF data (minerals associated with the deposit were known). This means that machine learning and multivariate classification can be used to classify measured spectra on the occurrence of certain minerals or mineral mixtures. By taking measurements at a sub-mm spatial resolution, it is then possible to quantify the mineralogy on intervals in the order of tens of centimetres large by counting the number of measurements in which a particular mineral was identified. For the sample shown in Figure 2, for example, this approach would show a higher concentration of Zn- and Cu-bearing minerals over the 140-240 mm positions compared to the 0-100 mm positions. If LIBS or XRF drill core scanning is applied to hundreds of meters of drill core from an ore deposit, this approach can likely be used to accurately delineate higher and lower grade ore zones and distinguish different ore types. Furthermore, relatively small veins and fractures can be identified, which may provide a better understanding of the geological processes that are associated with mineralization. This can be used to improve deposit models and better target physical sub-sampling for geochemical assay.

The main advantage of LIBS over XRF for drill core scanning is that the data acquisition speed of LIBS is much higher. The LIBS instrument that was used in the test can acquire LIBS spectra at a frequency of 10 Hz, which means that scanning a meter of drill core at 0.1 mm resolution takes about seventeen minutes. However, measurement frequencies of 1 kHz are also possible for LIBS applications (e.g. Rifai et al., 201), which would reduce the scan time for a meter of drill core to only ten seconds.

The XRF instrument that was used in the test needs at least ten seconds for a single measurement and longer measurement times might be needed to acquire data on elements occurring in low concentrations. Furthermore, the range of elements that can be detected depends on the excitation energy that is used, which relates to the voltage that is applied to the X-ray tube. XRF measurements using three different excitation energies are needed to obtain

accurate information on the full range of elements. Additionally, the XRF instrument needs to be in contact with the sample during the measurement, and about six seconds are required to relocate the instrument between measurement locations. This means that scanning a meter of drill core at 0.1 mm resolution by using three excitation energies and ten seconds of measurement time takes almost six full days. However, this can be significantly reduced by decreasing the resolution and number of excitation energies at which the measurements are performed. Scanning a meter of drill core at 1 cm resolution using only one excitation energy can be done within thirty minutes.

Another advantage of LIBS is that it is possible to detect light elements. Especially the ability to detect carbon, oxygen and sulphur provides significant benefits for drill core scanning since these elements can be used to distinguish between mineral groups such as oxides, carbonates, sulphates and sulphides. Additionally, the ability to detect hydrogen could potentially be used to characterize mineral hydration, which may be relevant when investigating ore deposits associated with hydrothermal alteration.

An advantage of XRF over LIBS is that there is a lower chance that the emission lines overlap with the lines of other elements. As was mentioned in the introduction, certain transition metals produce many different emission lines in a LIBS spectrum which may prevent the accurate detection of other elements. Additionally, signal to noise ratios and detection limits of XRF and LIBS can be different. This means that for specific elements, XRF might provide better results than LIBS and vice versa.

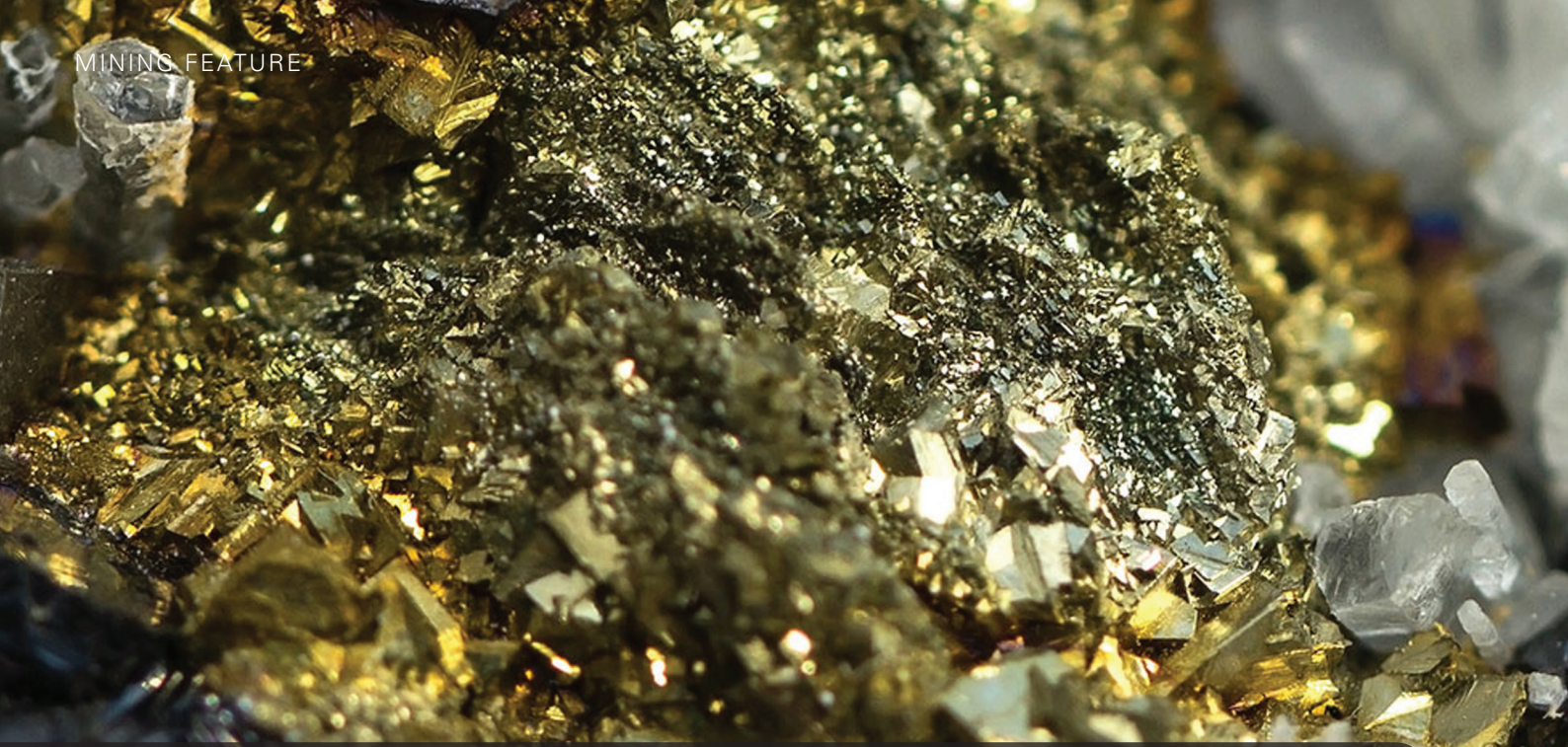
CONCLUSIONS

Testing the LIBS-XRF core scanning prototype on a drill core sample of a polymetallic sulphide ore showed that LIBS and XRF produce similar results for all the significant elements of which the sample is composed. By using either the LIBS or XRF data, it was possible to identify and map the occurrence of economically essential minerals that can be used to characterize ore grade. Differences between the results of LIBS and XRF were also observed, which can be explained by differences in the size of the measured surface area, signal to noise ratio, and detection limits of LIBS and XRF. Additionally, light elements such as oxygen or carbon that were detected with LIBS could not be identified with XRF.

Whether it is better to use LIBS or XRF for geochemical mapping of drill core samples depends on the specific goal of the application. This is mainly due to the detection limits that are associated with each technique, which rely on the mineral matrix in which an element resides (Radziemski & Cremers, 2006; Kadachi & Eshaikh, 2012). As was shown in this study, it is possible to combine LIBS and XRF in drill core scanning to allow a complete characterization of the composition of samples.

The LIBS-XRF core scanning prototype is a transportable unit that can be operated in the field. LIBS can be used to rapidly scan drill cores because of the relatively high scanning speed that can be achieved. This is especially advantageous when drill core scanning is applied in large mineral exploration projects in which hundreds of kilometres of drill core samples are produced. Drill core sections that are of particular interest can be further investigated using XRF. Especially for determination of the content of certain trace elements such as arsenic, XRF may provide higher precision than LIBS. wn

For References, email minx@saiee.org.za



Seven trends shaping the future of the mining and metals industry

BY | NICOLAS MAENNLING AND PERRINE TOLEDANO

The mining and metals industry is recovering from one of its most difficult periods in decades. Market volatility and a downturn in commodity prices have created a new normal where cost cuts, automation and operational efficiency are vitally important.

Meanwhile, industry-specific issues related to regulation, geopolitical risk, legal limits on natural resource use, shareholder activism and public scrutiny have created additional challenges. While we believe that demand for minerals will grow in the coming years, several trends will determine which types of mining companies will prevail in the future. We have identified the following seven drivers that we believe will shape the mining and metals sector.

1. TRANSITION TO A LOW-CARBON ECONOMY

Demand for most minerals is projected to be high to achieve the energy transition. While fossil fuels have helped to improve living standards around the world since the 18th century, their associated greenhouse gas emissions have led to global warming.

To avoid reaching temperatures that will have catastrophic consequences for the planet, countries must decarbonise their energy systems by the middle of this century. Given that low-emission energy and transportation systems are more mineral-intensive than their fossil fuel-based counterparts, the transition provides an excellent opportunity for the mining sector.

At the same time, the mining sector will have to reduce its emissions. Mining

companies that power their operations with renewable energy, operate electric or hydrogen-powered truck fleets and integrate recycling in their value chains will be best placed to sell low-carbon premium minerals.

2. ACCESS TO RESOURCES

Companies will need to venture into frontier mining areas. As world-class mineral resources in low-risk areas become exhausted, mining companies must either master new technologies for extraction and processing or venture into frontier areas where an extraction has not previously been economically viable.

Automation and digitalisation will result in more targeted and efficient mining, which could further be enhanced through technological breakthroughs in areas such as in-situ leaching (a mining process used to recover minerals such as copper and uranium through boreholes drilled into a deposit), block caving (an underground mining method that uses gravity to exploit ore bodies located at depth) or biomining (a technique for extracting metals from ores and other solid materials typically using prokaryotes or fungi).

Mining jurisdictions with higher perceived risks may see increasing levels of interest from investors. In the search for high-grade ore deposits, deep-sea and asteroid mining will be increasingly explored by governments and companies. While these technologies will open up new ways for mining companies to optimise the valorisation of existing resources or allow access to new ones, they are unchartered territory in terms of business models, processes, and potential social and environmental externalities.

3. NEW WAYS TO FINANCE MINING

As mining companies try to limit risk, novel financing and production models

Future of mining

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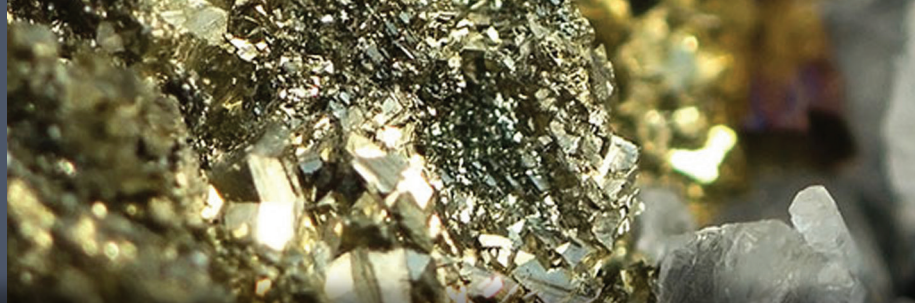

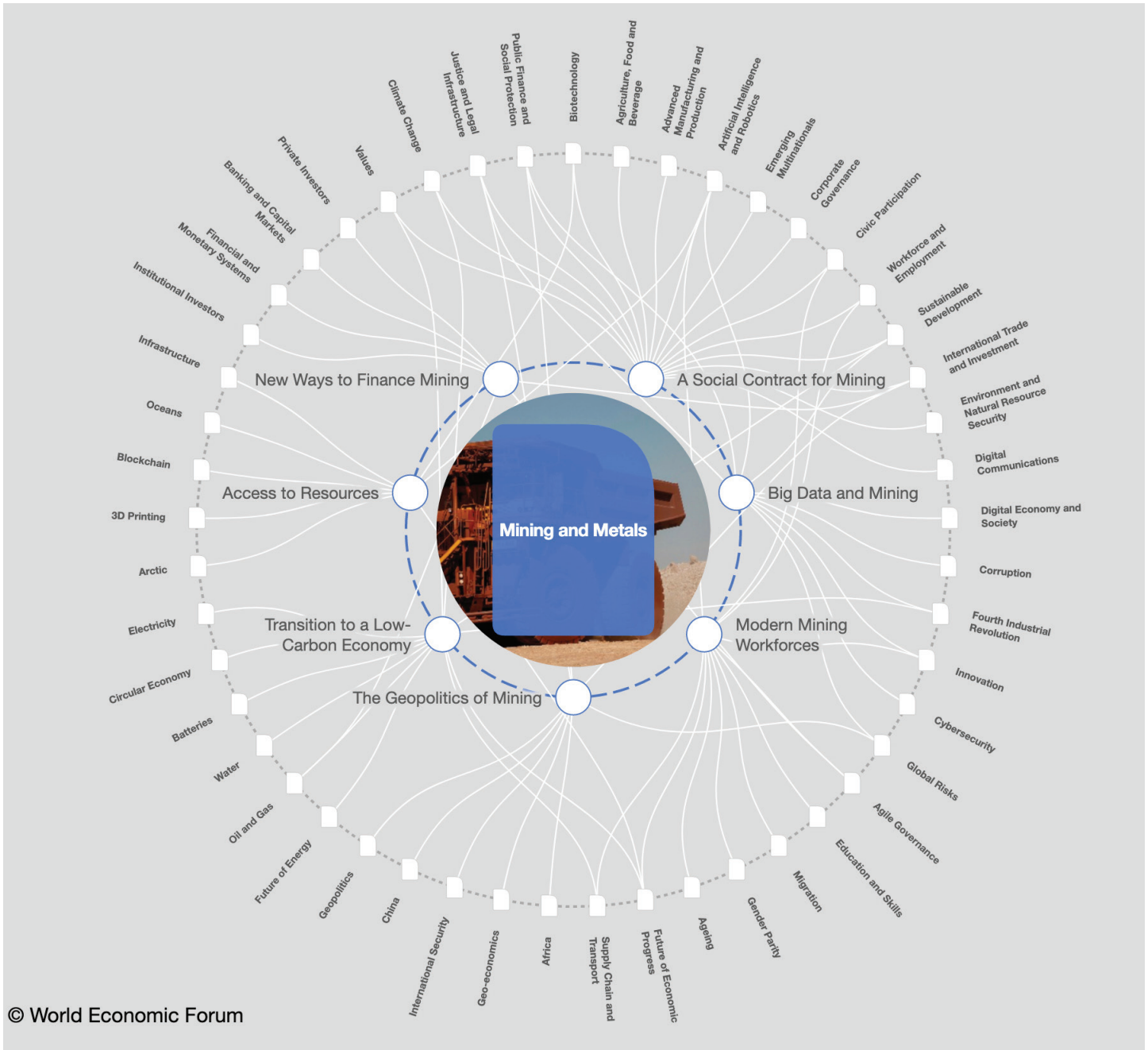

Figure 1: Mapping the connections in mining.

will become more common. After demand from China triggered a commodity boom in the first decade of the 21st century, prices collapsed, and mining companies were forced to focus on reducing debt ratios and improving their balance sheets. Alternative financing solutions were developed, such as royalty and metal stream agreements that reduce the burden on mining companies' balance sheets.

To spread the risk of new capital-intensive projects, these financing solutions are likely to continue to grow.

Companies may also seek to develop joint ventures similar to those observed in the oil and gas sector to reduce their exposure to a particular project or jurisdiction and may even consider service agreements.

4. A SOCIAL CONTRACT FOR MINING

Creating real benefits for communities near mine sites will be essential for successful new projects. Obtaining the 'license to operate' from local communities has been a challenge for the mining industry in recent years. Many proposed projects have been rejected, and protests have disrupted operations.

With a record number of mines nearing the end of their life and insufficient money being set aside for remediation; with new mining projects increasing the sector's footprint without necessarily providing additional employment opportunities at the local level due to automation; and with increased water stress and extreme weather events due to global warming: local opposition to mining is likely to increase if no new business models are developed that benefit the affected communities.

5. BIG DATA AND MINING

Data transparency to aid the mining industry's relations with stakeholders. Collecting and processing massive amounts of data will be essential for mining companies as they digitalise and automate their operations. What data should be shared and made transparent will continue to be a significant area of debate.

Governments will seek to further push for disclosure of subsidiary structures to address tax base erosion, and consumers will seek to increase value chain transparency. Investors will use the proliferation of non-financial data to assess the risks of their mining portfolios better, and civil society will continue to push for companies to go beyond the mandatory EITI Standard.

Impacted communities are particularly interested in accessing data that capture the externalities that affect them. It will be essential for companies to work together with other stakeholders to understand the types of data that should be made available and the appropriate format that data disclosure should take, to ensure standardisation, usefulness and impact.

6. THE GEOPOLITICS OF MINING

Mining companies must navigate rising geopolitical risk and economic protectionism. Growing popular resistance to globalisation and free trade is altering politics, and directly affecting the mining and metals sector. Policymakers in mining jurisdictions are increasingly trying to enact local content laws and regulations which require minerals to be processed before they are exported.

At the same time, import restrictions on semi-finished products such as steel and aluminium are at the centre of recent trade disputes. Trade wars and increasing protectionism are likely to dampen global commodity demand and disrupt the value chain of mining and metals companies. In the 'critical minerals' sector, which is central to high-tech and future-oriented industries, this trend is further complicated by market consolidation in the hands of a few players. Further consolidation, geopolitical manoeuvring and muscle-flexing could create challenges for companies that have so far prospered under a system of relatively free trade - while creating opportunities for domestic projects that might not be economically viable without government intervention.

7. MODERN MINING WORKFORCES

Maintaining an open dialogue will be essential as mining companies try to revamp their employee base. Constantly evolving technologies and business models will require mining company employees to develop new skills. The sector will have to increasingly compete with the IT sector to attract top talent from universities to drive its digitalisation and automation processes. Governments and companies will have to work together to help transition workers that cannot be absorbed by an automated mining sector to new activities through retraining and transitioning programs.

The speed at which mining companies will be able to roll out new technologies at their mine sites will be strictly linked to the host government's and labour unions' acceptance of reduced employment and procurement opportunities. As such, these actors need to be involved in the decision-making around the transition and in strategising policies to support those who will be negatively affected. wn

Automation and AI:
Implications for African Development Prospects

Now that computers are capable of taking the jobs that require brain as well as brawn, it may appear there is little left for humans to do. There are many scary forecasts of the capacity of automation and Artificial Intelligence (AI) to replace a lot of workers very fast. Self-driving vehicles may wipe out opportunities for taxi drivers and truckers, for example. Brynjolfsson, Rock, and Syverson note there are 3.5 million people employed driving vehicles in the US. If automation reduced that to 1.5 million, that alone would increase total US labour productivity by 1.7 per cent, but it would also leave two million drivers looking for work.

BY | CHARLES KENNY

In 2013, Oxford economists Carl Frey and Michael Osborne made waves by predicting that 47 per cent of US employment was automatable over the next two decades, with a higher estimate for developing countries. Erin Winick of Technology Review subsequently produced a summary table of job losses and gains estimations on automation. Some of the worldwide figures are in Table 1. There are two sides to the ledger, but some of the predicted job loss numbers at the global level are considerable.

The forecasts suggest bad news for Africa in particular, given concentration in types of low-skill jobs that might be easy to automate, rising working-age populations,

and already far too few good jobs to occupy the existing population. Arntz et al. suggest the share of workers at high risk of automation is 40 per cent amongst those with lower secondary education and above 50 per cent for those with primary or less education.

Advanced manufacturing and AI applications, including automated call centres, might even reverse the trend towards manufacturing and low-skilled services moving to developing countries. That would imperil a recent run of global income convergence. And there have been cases of impact already: Foxconn replacing 30 per cent of its workforce when it introduced robots and 1,000 lost jobs in Vietnam when Adidas shuttered a factory and moved production to *"speed factories"* in Germany and the US. If this is the beginning of a trend, it would be harmful to African development prospects.

Dani Rodrik notes that the move towards fragmented production—global value chains that have proven vital to manufacturing growth in countries, including China—has declined since 2011. Worse, analysis by Rodrik and colleagues finds that for outputs produced in global value chains, the comparative advantage of those countries further behind was already loosening. Wage competitiveness is not a significant determinant of participation but proximity to major markets, human and physical capital, institutional and logistics capacity all matter. This compares to products that were not part of global value chains, where wage competitiveness was the (only) factor of those examined which mattered for location—an important reason why manufacturing traditionally helped lower-income countries catch up. Connected to and exacerbating these problems, we have seen a declining job-intensity of exports overall. And the global shift in demand towards (less-traded) services suggests challenges for the next generation of countries hoping to use manufacturing exports to develop.

Rodrik suggests that as a result of current trends, *"[a] new [development] path will*

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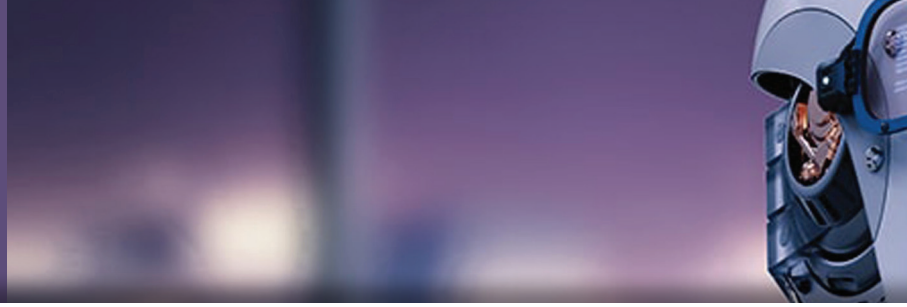

When	Destroyed (m)	Created (m)	Estimate by
2020		1.0-2.0	Metra Martech
2020	1.8	2.3	Gartner
2021		1.9-3.5	IFR
2022	1,000		Frey
2030	2,000		Frey
2030	400-800		McKinsey

Table 1

have to be invented. The broad contours of this alternative are easy to state. It will be a model based on services. It will focus more on soft infrastructure—learning and institutional capabilities—and less on physical capital accumulation—plants and equipment." But productivity advances in services may be harder: partial sectoral approaches stimulating export-oriented industrialisation will have to be replaced by "*massive economy-wide investments in human capital and institutions.*" If that is true, Africa's small markets, burdened with an expensive labour force and considerable infrastructure and institutional challenges, may well fall further behind.

At the same time, there are reasons to doubt the pessimism. Concerns with the impact of labour-saving technology is a longstanding tradition. The Robopocalypse has been nigh for at least 80 years, and the idea that automation would crush the working man has been around even longer (see Figures 1 and 2). Keynes predicted technological unemployment in the 1930s, Leontief in the 1950s, and Heilbroner in 1965. There was another peak of concern in the mid-1980s (see Figure 3). Moore's Law—the observation that the number of transistors on integrated circuits is doubling about every year—is increasingly invoked as evidence we are on the cusp of a revolution. Still, the Law dates back over a half-century, to 1965. It was previously rolled out during discussions of the forthcoming US productivity miracle in the 1990s—but jobs did not go away then, and global development continued.

This note reviews some of the literature around AI, automation, jobs, and development prospects with a focus on potential implications for developing countries and in particular for Africa.

It makes the following arguments: First, automation has long been a vital part of development, and Africa needs more of it. Second, the sector or occupational effects of labour-saving technical change on jobs and incomes can be harmful, but (at least to date) new jobs keep being created in the economy as a whole thanks to the demand generated by higher productivity. Income concentration and job losses caused by robots and AI to date have been limited, and policy appears to have mattered far more to trends in inequality.

Third, labour-saving technologies might reduce the convergence prospects of a region that has a lot more labour than capital. Manufacturing (export) jobs are not going away yet, and there are still hopes for developing countries to use the manufacturing route to development. And, fourth, the ongoing ICT revolution may present new opportunities for developing countries to speed growth. This is not to suggest the fears of development pessimists are ungrounded—challenges will inevitably appear. But the evidence to date indicates at least some reasons for optimism about Africa's future economic performance even in the face of smarter robots.

THE NEW YORK TIMES, SUNDAY, FEBRUARY 26, 1928. XX 3

MARCH OF THE MACHINE MAKES IDLE HANDS

Prevalence of Unemployment With Greatly Increased Industrial Output Points to the Influence of Labor-Saving Devices as an Underlying Cause

Figure 1: The New York Times blames machines for unemployment in 1928.

Figure 2: Der Spiegel predicts Robopocalypse in 1964, 1978, and 2016.

Figure 3: Appearance of the phrase "automation and employment" in books over time.

PRODUCTIVITY IS GOOD

Automation has been a vital part of economic growth, and that growth has always involved shifting employment patterns. The mechanisation of farms—replacing human and animal labour with tractors and combines—is a vital factor in allowing the US to produce far more food than it consumes even though the proportion of workers in agriculture has declined from 74 per cent in 1800 to around 1.5 per cent today. Just between 1940 and 1980, agriculture lost four percentage points of its employment share each decade in the US.

And automation helps to account for the fact that employment in pin factories in the UK fell about 99 per cent between 1820 and 1960 while output exploded. Adam Smith suggested workers operating on their own could produce about ten pins a day. In a factory using the technology of his time (the 1770s), he estimated they produced 4,800 pins each a day. By the 1970s, pin factories were producing 800,000 pins per day per employee. Weaving productivity has increased over 200-fold over a similar period. Again, William Nordhaus has explored the multiple-magnitude drop in the price of light over the last few centuries. This is why impoverished people worldwide can afford pins, cloth, and light. Robots are only one of the more recent entries in a huge long line of labour-saving technologies that have made the world better off.

Automation does considerably change what people do for a living. In 1850 the average worker produced around one-hundredth of a ton of steel or a yard of cloth each day. By 2000 it was more than half a ton or 200 yards of fabric. The change was associated with both increased worker wages. It increased consumption, as well as initially with increased employment, but price elasticity of demand did eventually fall—and we do not consume 200 times the cloth we did in 1850. (We consume closer to 100 times the amount).

In both textiles and steel, suggests Bessen, most of the jobs in rich countries have disappeared since 1950 because of growth in labour productivity without compensating the increase in demand. (In textiles, the number of workers declined from 350,000 to 120,000 between 1950 and 1995.)

But Mokyr et al. noted that while the industrial revolution killed a lot of jobs in home weaving, it created new jobs for mechanics, supervisors, accountants. *"Technological progress also took the form of product innovation,"* they note, *"and thus created entirely new sectors for the economy, a development that was essentially missed in the discussion of economists of this time."*

Elevator operators in the US demonstrate the full cycle of innovation creating and then destroying particular jobs. Their numbers in the US climbed from zero in 1860, to 497 in 1870, to 114,473 in 1950 before declining back towards zero by 1990. Pinsetters at bowling alleys, motion picture projectionists, travel agents—many other activities have followed the cycle. Regarding new product innovation creating employment, there were 466,000 jobs related to mobile apps in 2012. Again, Mandel estimates that jobs in fulfilment centres and eCommerce companies rose by 400,000 from December 2007 to June 2017 in the US. This exceeded the 140,000 declines of brick-and-mortar retail jobs over the same period (fulfilment centre jobs also pay 31 per cent more than brick-

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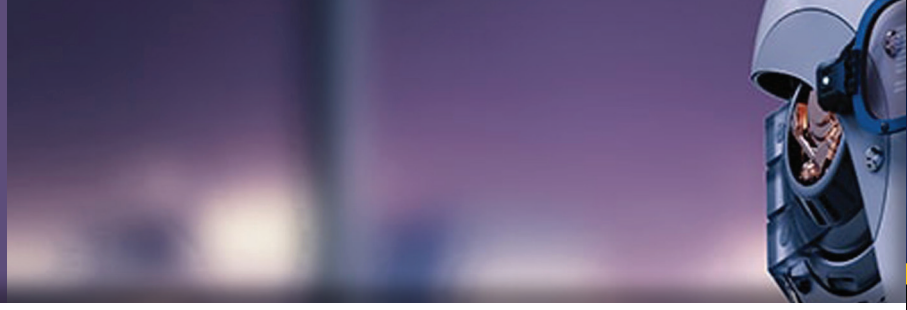

and-mortar retail jobs in the same area). New employment opportunities have spread to developing countries: Bangladesh has an estimated 650,000 online freelance workers.

Again, it is worth noting that automation has long replaced brains as well as brawn. Medieval guild professions involved many years of apprenticeship for careers from knife-making, armourers, and shoemakers to harness makers. When people used to think of calculators, they thought of human beings. Recorded music and television negated the need for live orchestras or wandering players at every performance. Not that live performances died out, of course—more people are making a living from live performances than ever before, and this example points to the fact that automation can also complement rather than replace existing employment. Bessen provides a case related to a new automation process: there are more bank tellers than ever before in the US despite a rise in the number of automated teller machines from zero in the 1970s to over 400,000 today (approximately one ATM for each human bank teller). Bank tellers do a different combination of tasks than they used to—less counting cash, more advice on products—but they haven't gone away.

That automation has not reduced employment helps to explain why the percentage of people aged 25 to 54 who are employed in the US, at 80 per cent, is only two percentage points below its peak in 2000 and up 18 percentage points from 1950 (output per worker has increased more than threefold over that time). Again, in 2016, there was no link between output per hour and the employment to population ratio across the Organisation for Economic Cooperation and Development (OECD)—it is not that places with higher capital stocks employed fewer people, they were just richer. Conversely, Mexico had a similar employment-to-population ratio to Luxembourg and Ireland but produced fourfold less output per hour (Furman and Seamans, 2018). The gap with poorer countries is even more significant—with low-income, low-automation economies seeing the considerable majority of their workforce either self-employed in activities like subsistence farming or informal, poorly paid jobs.

And until we meet the sated consumer, declining demand for one product will lead to higher demand for another. Autor and Salomons suggest that across the OECD, industry-level employment does tend to fall as industry productivity rises, but country-level employment rises as aggregate productivity rises. Productivity increases raise incomes, consumption, and employment so that positive spillovers more than outweigh the adverse own-industry employment effects to the rest of the economy. Again, this has involved a significant reallocation of workers into tertiary services which employ a disproportionate share of high-skilled labour, but it has not led to overall job losses.

Regarding the distribution of benefits from automation, looking at the world as a whole, if long-term rising productivity were consistently associated with rising inequality within countries, rich countries would be considerably more unequal than emerging nations. They are not. And if global productivity advance were associated with a decline in developing countries, higher output per capita in rich countries would be associated with lower output per head in poorer countries. It is not.

The reason why developing countries are poor is that they see low productivity, driven in part by limited automation. They are not intensively using technologies invented long ago to raise that productivity—technology, including tractors and combine harvesters, spindles, Bessemer plants, and electricity. What is behind the slow diffusion of such technologies is complicated. Still, again, poverty and lack of well-paid formal sector jobs are associated with low use of productive technologies, not high use.

Thankfully, we see rising productivity and shifts in employment share in low- and middle-income countries, including in Africa. In those countries as a whole, employment in agriculture, as a share of the total, fell from 53 per cent to 32 per cent from 1991 to 2016. Turning to Africa in particular, Yeboah and Jayne report that the period of strong regional growth since 2000 has been accompanied by a significant shift out of agricultural employment and rapid growth of wage employment. And if global productivity further increases in manufacturing, this will have considerable benefits for African consumers.

All that said, it would be better news if the productivity gains of newer advances, including robotics and AI, were globally widespread on the production side as well as the consumption side. So far, the more significant effect of modern automation has been in advanced economies. This does raise concerns that advances in automation may have inequitable effects between countries over the medium term, because of where and who gains from the increase in productivity. As Frey illustrates, there

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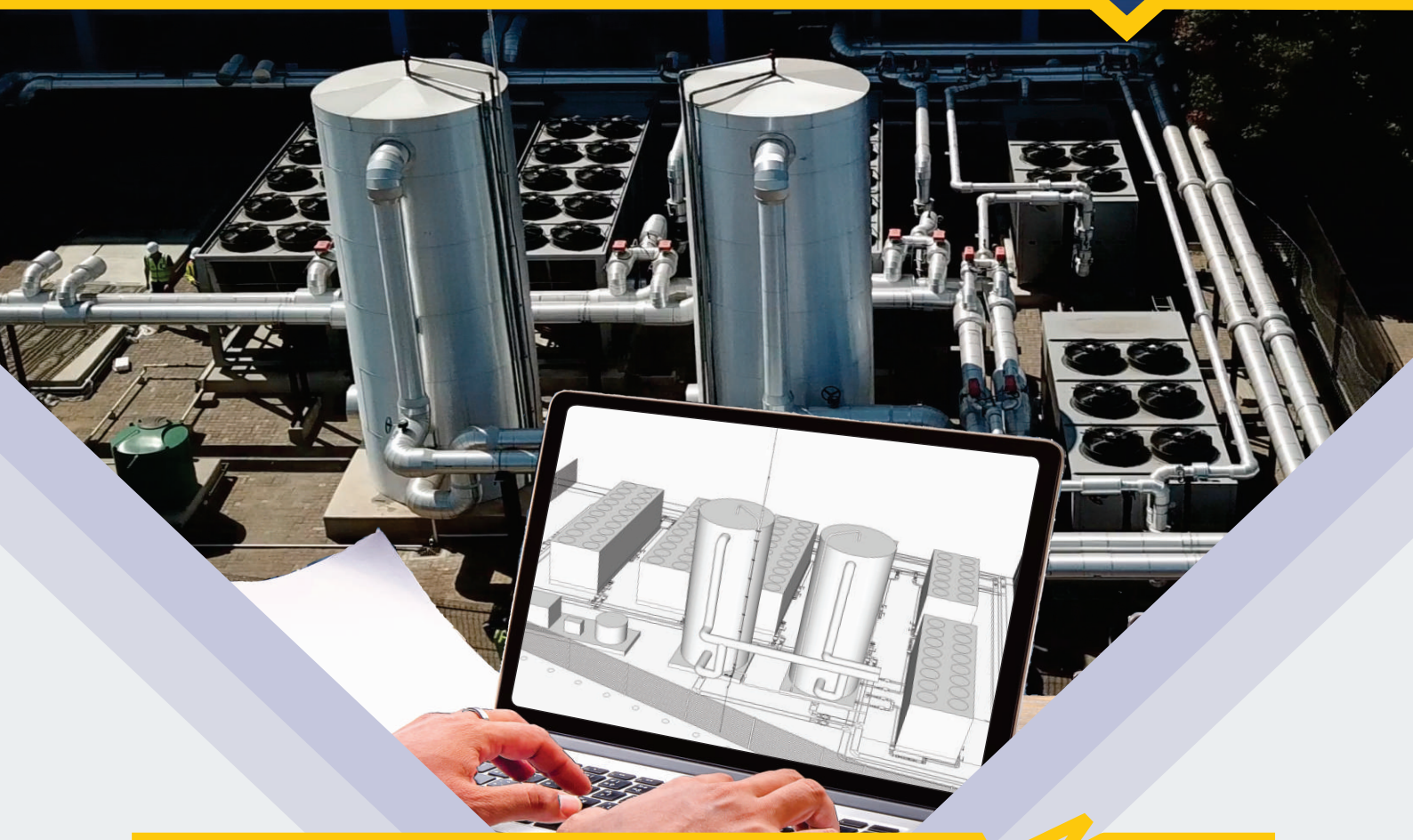

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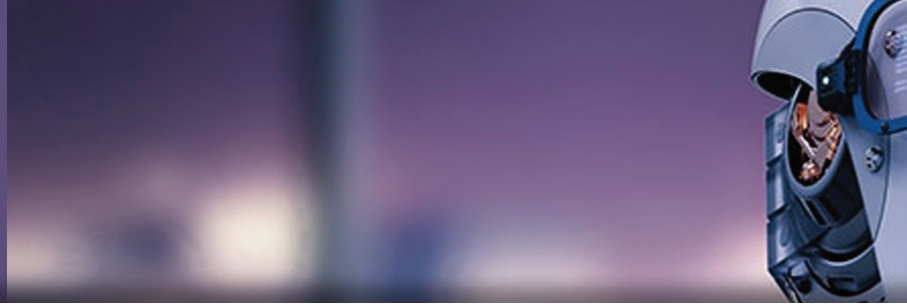

was a considerable gap between the start of the industrial revolution and benefits flowing to most British workers. And Allen notes that by the mid-nineteenth century, wages were (finally) rising in the UK, but by that time workers in other countries were suffering. In the 1830s, the British Governor-General in India reported, *"The bones of the cotton-weavers are bleaching the plains."* Both India and China saw absolute de-industrialisation.

The fear that the same phenomenon might occur—or already be happening. Today, with dramatic productivity gains appropriated by owners of capital in rich countries to the cost of workers in rich and poor countries, would be justified if; (i) there was evidence of significant and rapid spread of productivity-enhancing technologies in rich countries; (ii) job churn was rising as workers were rapidly replaced from automating industries facing saturated consumer demand; and (iii) manufacturing was declining in poor countries and global incomes were diverging. Later sections will suggest that evidence is still lacking for these concerns. Significant challenges are facing poor workers in rich countries and industry in developing countries, including Africa, but (as of yet) we are some way from bleached bones.

INNOVATION, PRODUCTIVITY, AND HOLLOWING OUT HAVEN'T SPED UP IN RICH COUNTRIES

Computers, robotics and AI have already had an impact on economies worldwide. The share of information processing equipment and software in nonresidential investment rose from 8 to 30 per cent between 1990 and 2012. A lot of jobs have been affected and some professions—including travel agents—notably shrank. Robot prices adjusted for quality fell 80 per cent between 1990 and 2005 and research by Georg Graetz, and Guy Michael from the London School of Economics suggests they have already increased productivity and overall economic growth.

But the evidence is so far absent of a major productivity shock. Robert Gordon notes the pressing question of the last few years in the US is *"why has economic growth slowed when innovation appears to be accelerating?"* He suggests the productivity growth slowdown can be attributed to *"declining productivity of research workers, diminishing returns to drug innovation, and the evolutionary impact of robots and artificial intelligence, which are replacing workers slowly and only in a minority of industrial sectors throughout the economy."*

Indeed, Bloom, Jones, Van Reenen, and Webb argue that *"ideas are getting harder to find"*–estimating, for example, that the number of researchers working on semiconductors has increased eighteen-fold since 1971. Still, Moore's Law (the doubling of chip density every two years) has applied throughout that period. They argue this demonstrates a declining return to research and find similar results in agricultural yields (25 times the researchers, a straight-line increase in yields since 1960 for corn) and drugs (measured by new molecular entities, clinical trials and publications). They note more broadly that aggregate growth rates are stable over time, but the number of researchers has increased enormously—twenty-three-fold since the 1930s.

Meanwhile, trends in labour productivity, capital investment, and IT and software investment all suggest a slowdown over the past 15 years. Brynjolfsson, Rock, and Syverson accept the *"paradox"* of growing use of AI and robotics and slowing productivity in the US and elsewhere (29 out of 30 countries with OECD labour productivity data saw a deceleration in productivity growth between the periods of 1995–2004 to 2005). They suggest many reasons why this may change, in particular, that there is often a lag between the start of new technology adoption and productivity effects due to the need to restructure. It wasn't until the late 1980s, more than 25 years after the invention of the integrated circuit, that the computer capital stock reached its plateau at about 5 per cent of nonresidential equipment capital, they note, and complimentary capital is required on top of that as well as restructuring and broader institutional innovation. This is undoubtedly plausible, but also suggests once again the likely evolutionary rather than revolutionary effect of AI adoption.

Regarding employment, if automation were forcing lots of people to seek new jobs, we'd expect rates of both firings and hirings to be on the up. Furman notes that labour market fluidity (both the job destruction and creation rate) has been declining since 1975. Atkinson and Wu suggest the level of occupational churn in 2010–15 is perhaps one-quarter of its concentration in the 1950-60 period. It has been steadily declining since 1980s. Similarly, employment share by occupation has been changing far more slowly in the last 15 years than in previous periods.

Autor and Salomons study the effect of automation across 18 OECD countries since 1970. Using TFP as well as for instrumenting using foreign patent flows and robot adoption, they find that new

automation has not reduced jobs but is associated with a declining labour share in value-added within industries. Again, Autor (2018) notes sales, office, and administrative workers, production workers and operatives accounted for 60 per cent of US employment in 1979 compared to 46 per cent in 2012. And Autor (2019) suggests that non-college educated workers in the US perform substantially less-skilled workers than they did decades earlier—although some of that will be the result of selection effects.

But Autor also accepts that the rate of decline of *"mid-skill"* employment has fallen since 2000 compared to earlier periods. There is an argument over how much hollowing out there is to explain at least in the United States. Mishel and colleagues suggest that lower-wage occupations have remained a small and stable share of employment since the 1950s (although their percentage share did climb 2.4 points 1999-2007). Middle-wage occupations have been steadily giving ground to higher-wage jobs over that time, and evidence for polarisation is weak, especially in the 2000s. Furthermore, the occupational wage level has been a weak predictor of changing employment share.

Again, Hunt and Nunn re-evaluate the hollowing-out phenomenon, suggesting that previous studies have found polarisation thanks to an artefact of occupation code redefinitions. They suggest the small change in workers earning middle wages in the United States since 1973 is primarily accounted for by a substantial increase in the share of workers earning high wages and a small decline in the share earning low wages. The evidence, they suggest *"rules out the hypothesis that computerisation and automation lie behind both rising wage inequality and occupation-based employment polarisation."*

Looking around the world, there is some evidence of hollowing out in developing countries, with increasing demand for nonroutine cognitive skills. That said, the need for routine cognitive skills has increased in countries including Botswana, Ethiopia, Mongolia, the Philippines, and Vietnam. More broadly, while people in developing countries do see a high return on investments in education—as high as15 per cent a year for tertiary education despite a considerable increase in the supply of such labour—inequality in developing countries has not uniformly increased. From 2007 to 2015, 37 of 41 emerging economies with data saw inequality remain flat or decline.

And we are not seeing the "cross-country hollowing" that would be expected were automation driving jobs away from mid-skilled workers. A. T. Kearney suggests that there were 300 cases of reshoring to the United States in 2014, a rise from previous years but still tiny considering that US MNCs have more than 25,000 foreign affiliates worldwide. And this does not account for continued offshoring amongst firms. Overall, US MNC imports from affiliates have continued to climb as a percentage of sales. Based on an ex-post accounting exercise of Asian countries, Bertulfo and colleagues (2019) suggest that greater automation within global value chains does drive down the demand for routine relative to nonroutine jobs. Still, the demand created by the higher-paid workers that remain appears to offset employment losses within GVCs.

Furthermore, the recent period of automation, AI and advances in robotics has been one of global income convergence. For the 43 countries the World Bank classified as *"low income"* in 1990, 65 per cent have grown faster than the high-income average since 1990, along with 82 per cent of the 62 middle-income countries in 1990. This is the reversal of a pattern since at least the 1960s.

If not automation, what is driving the rise of inequality in some countries? The answer appears to be a policy choice. Since the Industrial Revolution, there has rarely been the demand for unskilled labour to drive wages up fast enough to reduce inequality. It has only happened in a few periods in a few countries—perhaps the UK in the mid-nineteenth century and some East African miracle countries, but even then, only due to high export volumes. Usually, unskilled wages are kept higher by minimum wage laws, safety net systems, barriers to entry, and other interventions.

Rising inequality is a result of domestic policy choices—including anti-union legislation, lower corporate taxes, and less regulation of firms with monopsony power in the labour market. You do not have to look far beyond policy to explain inequality in the US, for example. The labour income share of the bottom 90 per cent in the United States fell as a percentage of the total share 1979 to 2000, by about ten percentage points, but has been flat since then. Beyond reduced tax progressivity, that timing suggests a role for the collapse of private-sector unions may have a significant role to play. The share was 24 per cent in 1973 and had fallen to 13 per cent by 2000. Again; the OECD estimates the real hourly value of the US minimum wage was $9.80 in 1979, fell to $7.30 in 2000 and was still only $7.30 in 2017.

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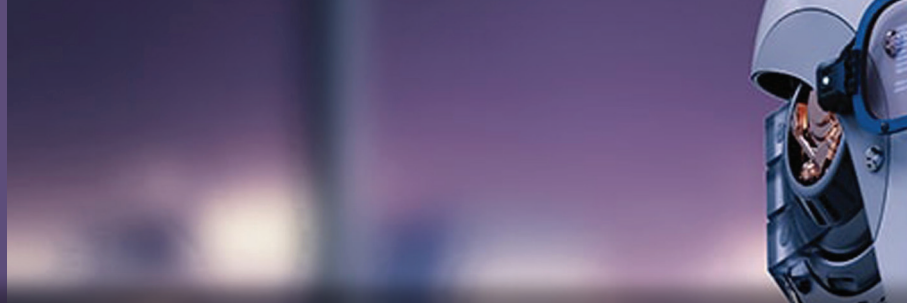

Ignacio Gonzalez and Pedro Trivin conclude in their analysis of *"The Global Rise of Asset Prices and the Decline of the Labor Share"* that *"we believe that the decline in the labour income share is not the irreversible consequence of technological or structural factors, but the result of policies that have boosted asset prices"*. They suggest the trend could be reversed by *"increasing competition or by imposing higher taxes on corporate distributions, like dividends or share repurchases."*

Across countries, globalisation has long been used as an excuse to attack labour rights and (so) reduce the labour share. But there is no need for that to be true—highly globalised countries in Europe have considerably stronger labour rights and lower inequality than the US, for example. And Guerriero (2019) notes that the variation of the labour share of income across countries is far more significant than the variety of the labour share of revenue within states over time (1970-2015). The labour share is positively associated with measures of democracy and negatively associated with income.

It is also worth noting here that, manufacturing jobs are not naturally *"better"* than the services jobs that are overtaking them—remember the child labour of the industrial revolution. The jobs were made better by strong unions and safety as well as wage regulation. Where that regulation is weaker, manufacturing jobs are not as prized. With services jobs, Rodrik (2015) notes that in many countries, they are associated with lower unionisation, more inadequate job protections and norms of pay equality. But they don't have to be associated with those features. Carre and Tilly (2017) study retail employment and suggest it does not need to be a low-quality, mostly part-time job as it is in the US. In France, for example, supermarket cashiers are paid more, are mostly full time, have lower turnover and higher productivity. Social norms, rates of unionisation and regulatory environments account for the difference. Even in the US, Costco and Trader Joe's offer better quality jobs than Walmart, for example, and Walmart jobs are relatively more attractive in other countries.

THE IMPACT OF ROBOTS IS STILL HARD TO SEE

If the macro picture fits ill with a story of rapid innovation pushing national and global income divergence over the past few years, there is still some evidence that computerisation and robotics may be affecting labour market outcomes. Bessen (2016) suggests that across occupations, greater computer use is associated with a rise in employment, although that impact is muted by the fact that other professions in the same industry see a slight fall in employment. And computer-using jobs are more skilled, potentially leading to growing wage inequality. Again, there is considerable OECD evidence of a move out of routine-task intensive jobs.

Less can be said about the widespread impact of robots in particular precisely because robots are not large-scale. Gordon notes that robots were first introduced into manufacturing in 1961 and by the 1990s were welding auto bodies and painting cars. But they have made few inroads outside of manufacturing and warehouses. Half of all robots shipped in the US in 2016 were for the automotive sector, which has a stock of robots per worker (at a little more than one per ten) that is 14 times higher than outside the automotive industry (Furman and Seamans, 2018). And while the number of robots shipped worldwide approximately tripled between 2004 and 2016, to around 300,000, this compares to about 77 million cars and 280 million computers that were sold worldwide in 2016.

It is worth noting robot density worldwide is highest in Germany, Korea, and Singapore, and all have high employment rates. (Germany has four times the number of robots per thousand workers that the US does.) That said, the introduction of robots was associated with rising wages for high-skilled workers, lower wages for low-skilled workers, and a higher capital share (Dauth et al. 2017). Acemoglu and Restrepo (2017) find that increased industrial robot usage by an industry in a commuting zone in the United States is associated with lower employment in that industry in that zone. However, their approach cannot detect many of the jobs created by automation (through lower prices, for example). And (even) taking the Acemoglu and Restrepo (2017) numbers at face value, robots account for less than 8 per cent of the decline in the share of the working-age population with a job since the 1990s (or 0.34 per cent of that population). Given they find non-robot IT investment is sometimes positively correlated with employment, the overall effect of automation is admittedly muted (Atkinson and Wu, 2017).

Mann and Puttmann link patents to their industrial use and though industry structure to their likely impact on commuting zones. The researchers suggest automation leads to declining manufacturing employment more than matched by increased services job growth. This a broader measure of automation than *"robots"* and the authors

conclude that their results combined with Acemoglu and Restrepo might suggest robots automating routine tasks in manufacturing may be bad for jobs while other types of automation outside of services may have a more positive effect on employment.

Looking across the world, there are very few robots in developing economies outside of China. That reflects, in part, the relative costs of labour and capital. Jorg Mayer (2017) notes that *"what is technically feasible is not always economically profitable"*—job displacement is most likely tasks that are routine and well paid. Food, beverages, and tobacco see high customary task intensity but also low compensation—the industry uses far fewer robots than transport equipment, with more moderate routine task intensity but far higher average salary. Textiles see particularly little robot use and low compensation despite high routine task intensity. This suggests many of the manufacturing industries most common in developing countries are there precisely because automation remains comparatively expensive. Perhaps this will change over time, but there is no significant evidence of it yet.

Regarding shifting comparative advantage, Micco (2019) suggests there has already been some impact of robots. In the last few years, developed countries have begun importing less from Latin American countries in sectors at particular risk of automation, as their stocks of robots per worker climb. De Backer et al. (2018) suggest that in the period 2010–14, adoption of robots in high-income country industries may have been associated with a slower rate of offshoring. Giuntella and Wang find that cities in China home to the industry, especially prone to robot use have seen lower employment and wage growth 2000-16.

That said, Artuc, Bastos, and Rijkers (2018) find that a 10 per cent increase in robot intensity in an automating industry in a rich country leads to a 6.1 per cent rise in imports sourced from less developed countries in the same industry (thanks to increased demand for parts and components) and an 11.8 per cent increase in exports to those countries. The authors suggest that this implies welfare gains to both rich and developing countries from robotisation.

Again, Artuc, Christiaensen, and Winkler (2019) find that the increase of 0.5 robots per 1,000 workers in the US between 2004–14 lowered growth in exports per worker from Mexico to the US by 3.3 per cent (this during a period where exports per

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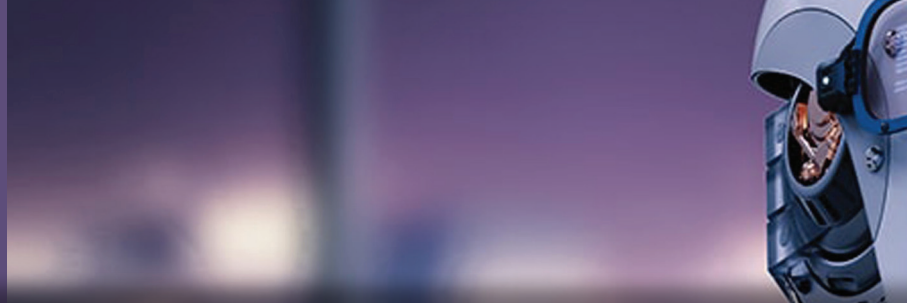

worker grew on average by about 110 per cent, suggesting a minor impact). Exposure reduced wage employment in areas where occupations were more susceptible to being automated but increased wage employment in other areas, leading to no net effect on manufacturing employment or employment overall.

MANUFACTURING JOBS HAVE MOVED BUT NOT GONE AWAY

Hallward-Driemier and Nayyar, using data from 1994 for 19 countries, suggest the average export-to-output ratio of manufacturing is 68 per cent compared to 6 per cent for services, and the share of blue-collar workers is 74 per cent in production compared to 31 per cent in services. Beyond being traditionally low-skilled and producing exportable goods, there is considerable evidence that manufacturing is a sector that benefits from economies of scale with strong forward and backward linkages, and that demonstrates technological spillovers within and between countries. These features have made it an essential source for growth in lower-income countries, especially in the past. Rodrik has shown that manufacturing has shown unconditional productivity convergence over the long term, even in countries with weak institutions or policies. He worries that automation and global value chains are eroding the advantage of low-income producers, increasing the share of skilled labour, and making other factors than low labour cost significant to competitiveness.

And Rodrik is concerned by the sustainability of growth by other means. While some parts of services share great productivity features, like automated manufacturing, these are comparatively low-employment high-skilled activities, suggests Rodrik. In Africa, service sectors with the best productivity performance typically shed labour while those that absorb labour have the worst productivity performance. Similarly, Hallward-Driemier and Nayyar suggest most service industries that exhibit *"productivity-enhancing"* characteristics (for example IT services) are unlikely to be associated with large scale employment creation for low-skilled workers, while low-skilled sectors are less likely to drive productivity gains. Tourism and retail trade may be exceptions.

More positively, the death of developing country manufacturing opportunity might have been overplayed. Over the longer term, it is developed countries that have witnessed a more significant decline in the manufacturing share of output—if from a higher starting point. In OECD countries, the average share of manufacturing as a percentage of GDP has been falling since at least 1950. Lawrence (2018) notes the (decades-long) trends of productivity growth in US manufacturing combined with unresponsive comparative demand has led to a declining share of manufacturing employment (a trend only marginally impacted by growing globalisation). The percentage of consumer spending on goods declined from 62 to 33 per cent 1947–2017. The US long-term pattern is typical of that seen in industrial countries, including those (like Germany) that have a manufacturing trade surplus.

But turning to develop countries, while Szirmai (2009) notes developing countries on average have smaller manufacturing sectors and larger services sectors than now-rich countries did at the same stage of development. China experienced a peak in manufacturing employment share that was higher than the maximum in the average advanced economy, and China is a vast country. It may account for some of the premature peakings elsewhere. Haraguchi et al. (2016) find that across developing countries as a whole, manufacturing employment has climbed from below 10 to closer to 15 per cent over the past few decades, primarily driven by China.

As developing countries get more prosperous, and despite a likely decline in the share of consumption going to goods, global demand for manufactured products will continue to climb. And the associated manufacturing employment may shift. Hallward-Driemier and Nayyar suggest wages in Chinese manufacturing have risen 281 per cent 2003–2010. There is already some evidence of jobs moving as a result: just in the first decade of the twentieth century, the share of the labour force employed in agriculture in sub-Saharan Africa declined by roughly ten percentage points, with a rise of 2 per cent in manufacturing and 8 per cent in services. In Kenya between 2000–2007, the share of production in employment climbed more than seven percentage points 2000–2010. From a low point of 9 per cent of exports in 1981, sub-Saharan Africa's manufacturing share of exports was 27 per cent in 2017. Chinese FDI in manufacturing in the region has climbed considerably, and there were as many as 100,000 factories owned by Chinese businesspeople on the continent in 2017.

SERVICES OPPORTUNITIES ARE GROWING

At the same time, other pathways to prosperity appear to be emerging. There is evidence of a rising impact of services on growth compared to manufacturing. Across

the countries in Hallward-Driemier and Nayyar's sample, the average value added per worker in services, at about $27,000, is slightly higher than in manufacturing ($26,000). Szirmai's survey of the literature suggests that manufacturing as a source of growth was more important in the period 1950–73 than since then, when services have been the more powerful contributor. Ghani and O'Connell (2014) suggest services convergence across countries has been more rapid than manufacturing convergence 1990–2010, and services have experienced faster growth rates and created more jobs. Productivity levels in a range of services are converging to the global frontier—including trade and accommodation (the fastest growing employer amongst service industries in developing countries), transport and communications, and financial intermediation and business services. Note also that cross-country convergence began after the average share of manufacturing in GDP across developing countries started to decline in the 1990s.

Looking at India in particular, Amirapu and Subramanian (2015) find that services as a whole have seen labour productivity grow more rapidly than registered manufacturing 1984–2010. A level of productivity almost twice that of production as a whole and more than twice the productivity of the aggregate economy as a whole. Parts of the services sector, including financial services and insurance as well as real estate and business services considerably, outperform registered manufacturing. Eichen- green and Gupta also report the emergence of what might be thought of as stepping stone tradeable service jobs in the rural areas of India, employing workers with some high school education who can do basic data entry and read forms—they earn four times the agricultural wage which is still one half the salary of workers in Bangalore.

Amirapu and Subramanian accept that while several service subsectors share the virtues of high productivity and domestic and international convergence, they also share the feature of formal sector manufacturing of being relatively skill-intensive. In 2004/5 in India, 77 per cent of employees in registered manufacturing firms had at least primary education and 43 per cent secondary education. In services, 78 per cent had at least primary education and 48 per cent secondary education. The good news is that developing countries are far better placed to fill higher-skilled jobs than in the past. The stock of educated workers in low-income countries is far higher than it was in high-income countries when they were at a similar income level. The average number of years of education in the population 25 years and older in India climbed from 1.9 in 1980 to 5.4 in 2010.

Africa sees similar progress. In Kenya, for example, average years of schooling has gone from 2.5 to 6.2 years over the same period. Kenya's average years of education for the population 25 and above in 2010 is the same as Italy's was in 1980.89 And Newfarmer et al. suggest that Africa is already on the path to *"growth without smokestacks"*: service industries alongside food processing and horticulture are beginning to play a role in the region analogous to that played by manufacturing in East Asia.

Richard Baldwin suggests the future possibilities could be even more significant. The *"third globalisation"* is unbundling labour from its physical location through remote work, which could reduce (in production terms) the impact of migration controls, potentially allowing the global economy to benefit from some of the trillion-dollar bills on the sidewalk left by constraints on labour mobility. Baldwin predicts a *"globotics upheaval"* in which the US and European service sector and professional jobs are opened to direct competition from abroad—in other words, that large parts of the services sector will become as tradeable as manufacturing. He argues this trend will be supported by instant machine translation, improved remote communication, and collaboration. If this occurs, there would be considerable upside for developing countries, including Africa in terms of services exports. But it should be noted that the evidence for the third globalisation is as nascent as that for the impact of robotics (with predictions of mass offshoring around for more than a decade), and there are dissenting (if weakly evidenced) views suggesting improved communication might lead to concentration.

AFRICA'S OPPORTUNITY?

Will Africa be able to benefit from new opportunities presented by the potential decline of manufacturing in China alongside new service industries with the possibility to export? Most of the African output is currently very low productivity. Eifert et al. estimate that the same stock of capital and labour produces around 75 per cent less in Nigeria than it does in China, for example. The local business climate—the burdens of regulation, inadequate public service provision, and so on—is a severe impediment for many firms, and recognised as such by local firms in surveys. The "indirect costs" of this poor environment

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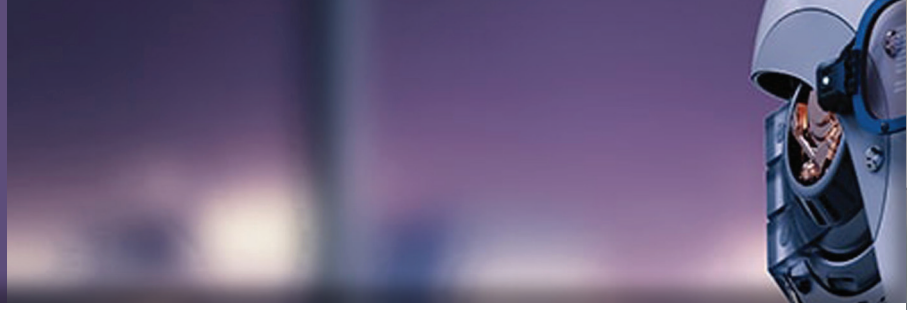

on productivity are significantly higher in Africa than elsewhere. That suggests amongst other things that a strong services sector is essential to both manufacturing and services export competitiveness, and helps to explain why so few countries outside of East Asia have managed to achieve rapid growth including through manufacturing exports. It also suggests that strong manufacturing export performance may proxy for a better environment for production in general—and that a better environment may be the key to rapid growth.

Rodrik's argument regarding the need for systemic reform still holds, then. Simons (2019) points out the challenges that African e-commerce startups, or global operators operating in Africa, face because the broader economic ecosystem is not in place to exploit models based on the institutional and infrastructural conditions of an OECD country.

Especially players that aim to focus on the local market *"consistently feel compelled to build out 'across the value chain' and take responsibility for multiple steps along that chain."* Konga, a Nigeria e-commerce startup, had to *"build its payment platform, courier network, anti-fraud program, fulfilment centres, call centres, and training system."* Fixing the broader environment for business will be a vital part of the challenge for the region to gain from the new opportunities presented by any diffusion of manufacturing jobs or Baldwin's *"third globalisation."*

That said, some output in the region approaches the global production frontier, including Kenya's agribusiness. It is not that the international system and the region's institutional legacy makes African competitiveness an impossibility. And advances in e-commerce may help improve the underlying business environment to the benefit of firms and employees alike. Mobile financial solutions have already revolutionised banking services in parts of the continent.

And Porteous and Ng'weno (2019) note that digital commerce and the gig economy are opportunities for informal workers rather than a threat, allowing a ladder towards formality through integration into the formal sector through finance, contracts, taxes, and eventual registration.

POLICIES FOR THE ROBOPOCALYPSE

It may be that we are on the cusp of a productivity revolution in rich countries that will create a global shockwave that flattens Africa's manufacturing prospects. On the other hand, we may not be. There are certainly reasons to doubt some of the forecasts, suggesting a massive technological change in the short term (not least, recent setbacks with autonomous driving, including the death of a pedestrian and the apparent failure of IBM's program to use the Watson supercomputer for cancer diagnostics).

Again, it may be that we are on the cusp of a revolution in the trade of services that will create enormous opportunities for developing countries ready to grasp the opportunity. That said, the previous over-estimates of the growth of global outsourcing might give us pause.

Either way, the policy prescriptions for robopocalypse or globotics revolution are similar. The World Bank's World Development Report 2019 suggests automation calls for three primary responses: investment in human capital and especially education; enhancing social protection; and taxes to support those policies, including property taxes, sin taxes, and carbon taxes. These all seem eminently sensible policies even if the change is evolutionary than revolutionary, and whichever direction it takes.

The broad news for African development prospects is reassuring. Automation increases incomes and is associated with more, not fewer, good jobs. The region could still benefit from a considerable expansion in manufacturing. While manufacturing jobs may be becoming more skill-intensive, education levels in Africa are higher than they were in industrialised countries only a few decades ago (even if learning levels lag further behind).

Again, there are increased opportunities in services exports as well as new tools to increase the productivity of domestic services. Evidence of an imminent third or fourth industrial revolution that might re-concentrate output in the wealthiest countries is lacking, and policy tools are available to reduce domestic pressures towards greater inequality.

All that said, the barriers that kept the region poor in the past are still likely to limit growth today, and efforts to expand markets, improve infrastructure and institutions, and build human capital remain as vital as ever. wn

References email minx@saiee.org.za

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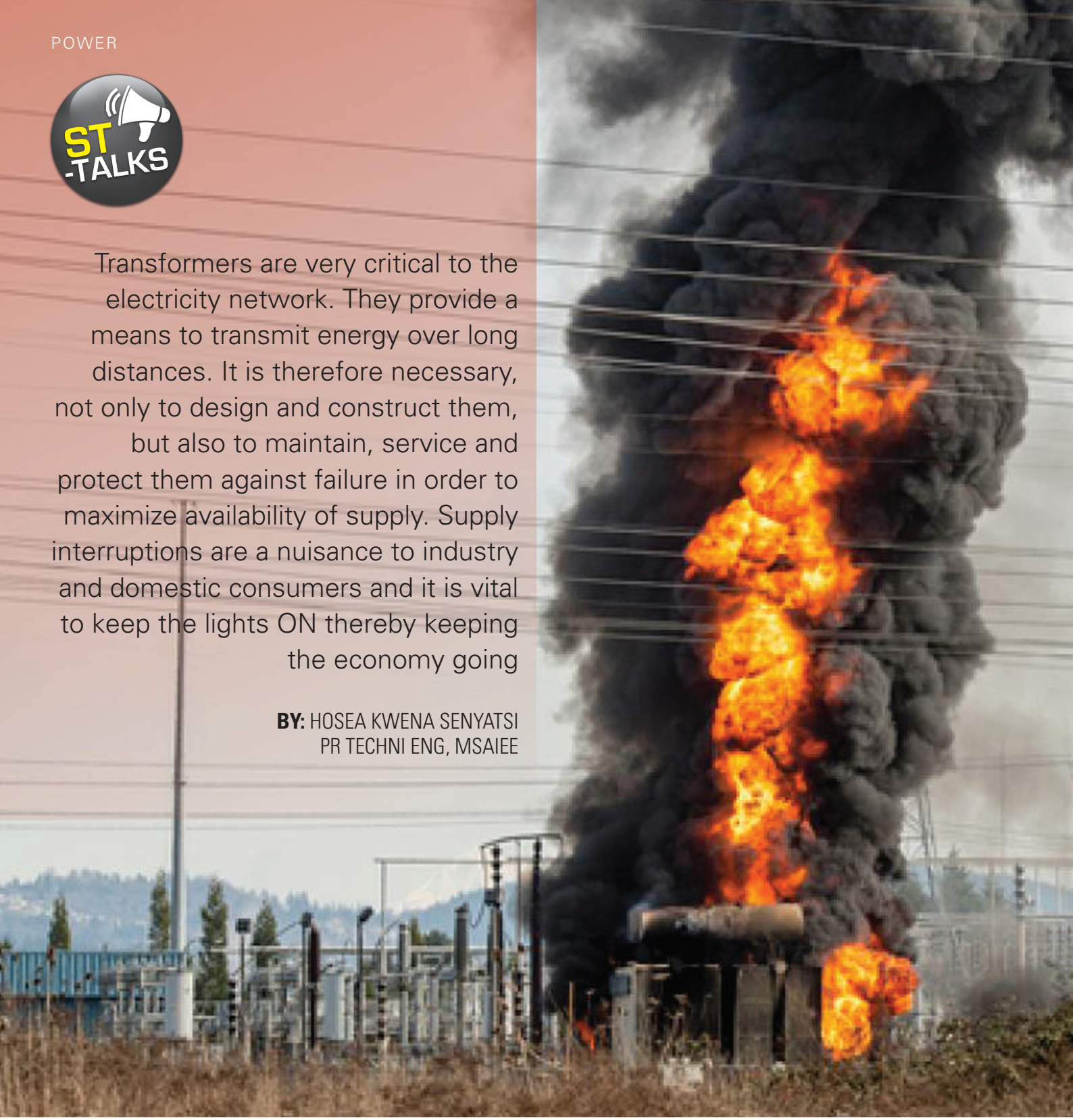
ST -TALKS

Transformers are very critical to the electricity network. They provide a means to transmit energy over long distances. It is therefore necessary, not only to design and construct them, but also to maintain, service and protect them against failure in order to maximize availability of supply. Supply interruptions are a nuisance to industry and domestic consumers and it is vital to keep the lights ON thereby keeping the economy going

BY: HOSEA KWENA SENYATSI
PR TECHNI ENG, MSAIEE



Oil-Filled Transformers are one of several types of transformers that power utilities install in their power systems. These transformers are manufactured with safety in mind. To assist an engineer, the use of protection devices such as Buchholz Relay, Pressure Relief Valve, Sudden Pressure Relay, Oil Temperature Indicator, Winding Temperature Indicator, imbedded safety devices, Gas Operated Relays, etc. are implemented.

These devices can protect the transformers against failures that are detectable, such as:

- Pressure Relief Valve: Pressure Relief Valves are suitable for slow pressure rise. Pressure developed during low impedance faults are extremely fast. Most transformers that have exploded have Pressure Relief Valves installed on them.
- Buchholz Relay: This device also cannot react fast enough to sharp pressure gradients.

Protection and Prevention of Fires caused by Power Transformers

- Electrical Breaker opening time: Usually breakers trip in 70-100milliseconds which is not quick enough as most of the explosive gases are generated within 2-10 milliseconds after short-circuit. Consequently, the tank pressure keeps increasing even after the breaker has opened.

Clearly, these devices can either fail or not act quickly enough to prevent a catastrophic failure. That is a reason why it is important for power utilities and companies to install fire protection systems to prevent transformer fires and protect their substation equipment from secondary fire as a result of transformer explosions.

CAUSE OF TRANSFORMER EXPLOSION

When an oil-filled transformer explodes due to internal faults such as short-circuit, an electric arc inside the transformer tank will create a tremendous volume of explosive gases. These gases are created in a space of milliseconds and at very

Transformer Fires

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high temperatures. As the arc expands, so does the volume of these gasses and the transformer tank will eventually explode due to static pressure increase inside the tank caused by pressure waves travelling inside the transformer tank.

These explosive gases that are at high temperatures will come into contact with oxygen and will ignite creating a huge fire all around the transformer. The protection devices installed on a transformer are thus slow and ineffective to prevent transformer explosions during short-circuit conditions.

Figure 1: Transformer Sprinkler System

TRANSFORMER FIRE PROTECTION TECHNIQUES

There are many systems that can be employed which can be traditional and technological.

The NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations includes guidelines to prevent transformer explosions and fires to avoid harm to plant personnel, loss of assets, environmental damages, and business interruptions.

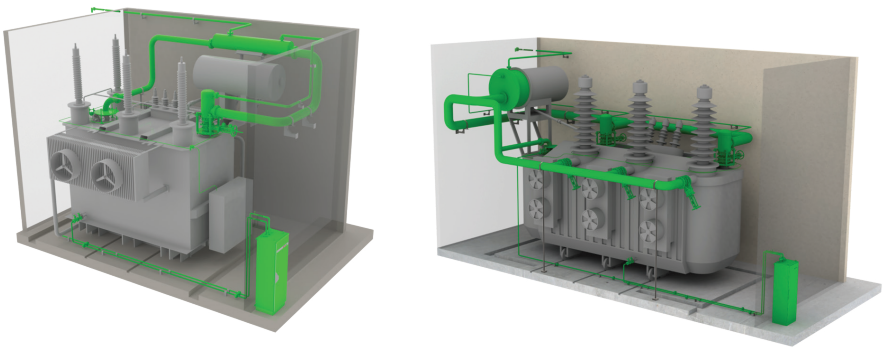

Figure 2: Sergi Transformer Protector System

- The traditional way of dealing with transformer fires is by installing a fire sprinkler system (High Velocity Water Spray System). The system is designed and erected with pipes running around the transformer. The pipes have nozzles that will spray water on the transformer to cool it and eventually extinguish the fire.
- The system will spray water at a rate of about 1 890L/minute for a duration of not less than 2 hours. This water can also find its way back into the municipal water system and can contaminate the water system with transformer mineral oil.
- To curb against this, transformers need to be installed on a plinth that is inside a bund area. This is to help contain the spill of both oil and the extinguishing water or foam. The mixture can then be pumped up into containers and disposed in terms of environmental management standards and legislation i.e. ISO14001.
- The NPFA 15 Standard for Water Spray Fixed Systems for Fire Protection provides the minimum requirements when designing, erecting, installing, testing, servicing and maintaining Water Spray systems as seen in the above example. These systems must be able to effectively control, extinguish and protect other equipment in the vicinity against exposure to Transformer Fires.
- The other method that can be used is the Fast Depressurization System. This system is reliable and also highly efficient. This type of system prevents the transformer from exploding by depressurizing the transformer tank. After the depressurization has taken place, the hot gas inside the tank is cooled by injecting an inert gas such as nitrogen inside the tank so that the generated hot explosive gases are not ignitable and safe opening of manholes

can take place for inspection purposes without risk of combustion.

- These methods can be installed to work independently or both installed to complement each other.

CONCLUSION

It is important that transformer fires be contained in case they break out to prevent further damage to other neighbouring equipment in the substation.

Also, prevention of water pollution and any other environmental contamination is just as important. Both methods are being used by power utilities and industry and the depressurization method is mostly preferred. Bund walls and fire walls are also ways of preventing the spread of fire to other equipment in the vicinity but when fire breaks out, it is crucial that it gets extinguished as soon as possible and contained.

If the creation of fire can be eliminated, as in the case of the SERGI TP depressurization system, it's even better.

It is also vital that the design and erection of these systems be done by trained professionals who are deemed competent and who are accredited in the installation, commissioning and testing of such systems.

REFERENCES:

NFPA Code 15:
Water Spray Fixed Systems for Fire Protection.

NFPA Code 850:
Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations.

Sergi-TP:
Fast Depressurization System

Global non-technical losses account for approximately $96 billion annually. The largest contributor to these losses is electricity theft which is attributed to access to electricity, affordability, socio-economic conditions and poor service delivery. South Africa is not excluded from this phenomenon, with electricity theft contributing to 10% of its total losses, highlighting its contribution of non-technical losses to global statistics of approximately 1.5%. Furthermore, the environmental impact resulting from fossil-fuel electricity generation in South Africa is on par 40% higher in global comparison and is highlighted to be the 14th largest emitter of greenhouse gasses globally, with non-technical losses compounding the situation. This article discusses the impact of non-technical losses and highlights the South African perspective, compared to global trends.

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Global utilities suffer commercial or alternatively defined non-technical losses of approximately $80-100 Billion per year. Non-technical losses (NTL) are quantified as losses, which are incurred because of poor administration, fraud, non-paying customers, and corruption, with the largest component attributed to electricity theft. *Gratis* electricity is also considered an NTL and is defined as free electricity provided to support poor indigent communities and, in some instances, certain employees and organisations.

Technical losses on the other hand are losses that naturally occur within power systems due to energy dissipation, and these losses are generally quantified and mitigated for. The loss equation is then highlighted as below in equation 1. It has been argued in literature that the significant component of losses found within the overall loss equation is attributed to the sum of the NTL.

$$\Sigma Total\ Losses = \Sigma TL + \Sigma NTL + \Sigma Gratis \quad (1)$$

NTL have a direct impact on the economy, social wellbeing, safety of the population and environmental plethora as a result. In this article, an overview of the impact NTL's has on the global situation will be

The Impact of Non-Technical losses

A South African perspective compared to global trends

discussed, and furthermore, the South African environment will be compared to these global trends.

GLOBAL TRENDS

It is estimated that out of 20 trillion kW/h produced globally on an annual basis 1.4 trillion kW/h are lost due to the phenomenon of NTL, furthermore it would suggest that utilities would have to generate more capacity to offset these losses in order to sustain energy demand to their paying consumers. Figure 1 illustrates the combined global (TL and NTL) losses for the past 6 decades. This seems to highlight and that the combined losses are directly proportional to energy demand requirements and suggest no real diminishing of the overall losses. These losses therefore still form a significant part of the generated capacity.

Figure 2, illustrates the losses per country and highlights the African continent as one of the regions where NTL's are still significantly ubiquitous. In 2004, it was estimated that in developing countries, the forfeited losses where 15% and that of developing countrieswere as much as 35% of the generated capacity. However, in 2014, these losses have not diminished and have been on the increase as highlighted in figure 1.

Literature highlights that Sub-Saharan African utilities present large inefficiencies and in 2009, it was recorded that on average; only 50% of generated electricity supply was paid for. Nigeria contributed the largest portion of these inefficiencies of which only 25% of the generated capacity was paid for, whilst Botswana, considered the best performing utility, recorded losses at 10%.

During the same period, the losses reported for South Africa were at 15%, and in 2017 these losses were further reported to be in the order of 9.15% as per the Eskom Integrated report for 2018, highlighting a marginal reduction in a period of almost 10 years. In a World Bank, report for 2016 it is highlighted that out of 39 countries investigated only 19 countries collected enough revenue to sustain operational costs. Figure 3 highlights the cost recovery for these 39 countries.

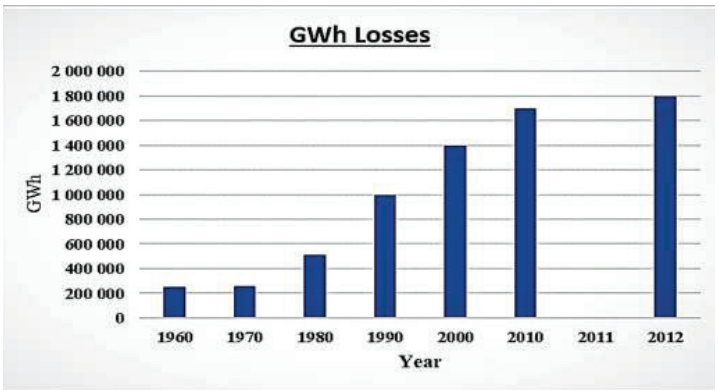

Figure 1: Global losses year on year (1960-2012).

Figure 2: World Losses per country.

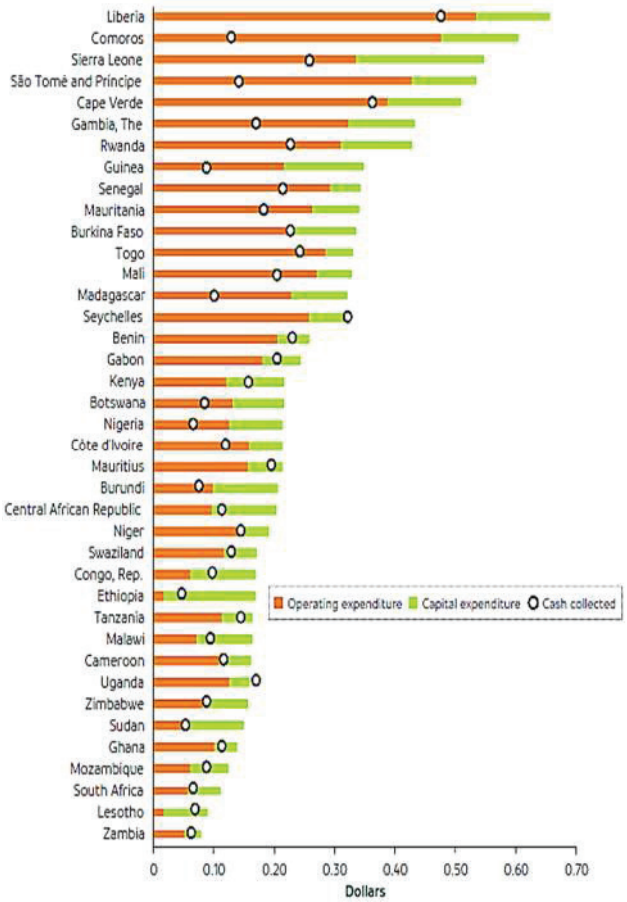

Figure 3: Cost recovery for 39 utilities in SSA.

Impact of Non-Technical Losses

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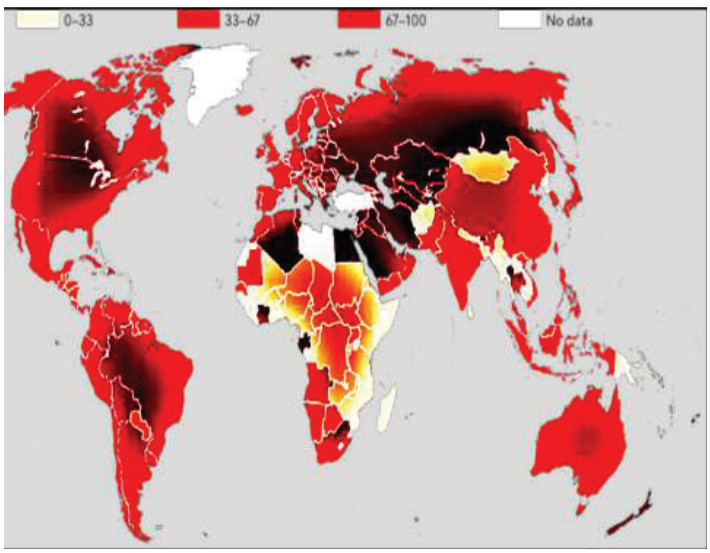

Figure 4: Global access to electricity (2016) [12]

Access to electricity as recorded in 2015 according to the World Bank, is on average 88%, and that the sub-Saharan African continent inclusive of some Southern Asian countries still face significant challenges to correct this. Figure 4 (2016) highlights the global access to electricity and indicates clearly the prevalence of the problem. Energy access in the sub-Saharan African region is still very problematic and it is estimated that only 1 out of 3 people have access to electricity, highlighting that approximately 633 million are still without electricity within this region. The current world demographics for 2018 constitutes a global population of approximately 7.7 billion people with an annual growth rate of 1.09%.

The sub-Sharan African continent however, accounts for just over a billion people with a growth rate of 2.66% down from 2.75% in 2015. This growth rate still signifies a higher rate than that of global trends and it is considered the fastest growing population in the world.

According to the 633 million people without access to electricity in the sub-Saharan African region will increase to 823 million people by 2030, this due to the current population growth. With this population rate in mind and compared to the rate of infrastructure development and electrification, it is argued that the status quo will remain the same. Post 2030, this latter comparison is however expected to start correcting by 2040 due to renewed initiatives employed by utilities and governments worldwide.

In regions where electricity generation is largely dependent on fossil-fuels high losses tend to contribute to high greenhouse gas emissions. Significant health risks due to poor breathing air, climate change, threat to food security, sea-level rise, floods and drought and diseases are all derivatives of the effect of burning fossil fuels in power plants. The environmental impact because of these losses are significant and worth mentioning in this article. It is estimated that the losses of 1.4 trillion kW/h represent carbon dioxide emissions of 1.2 trillion metric tons. It is further suggested that by employing initiatives to reduce these emissions by 33% would yield a reduction in required capacity of 53 gigawatts. This suggested reduced capacity is more than half of the total generated capacity of approximately 90 gigawatts in the sub-Sharan African region with more than half of this generated capacity found within South Africa.

As highlighted the largest portion of NTL are attributed to electricity theft. This phenomenon was first recorded in the "Daily Yellowstone Journal of March 1886- "*People who steal Edison's electricity*". The act of electricity theft is generally attributed to the result of no or inadequate infrastructure, poor service delivery, high electricity tariffs and high unemployment. These illicit actions exacerbate the poor revenue collection initiatives within utilities and collectively affect the economy and the environment. It is furthermore recorded to be the third most stolen item, in comparison to motor vehicle and credit card theft. Figure 5 highlights the global perspective on where these illicit actions are prevalent. From figure 5 a clear comparison is drawn between

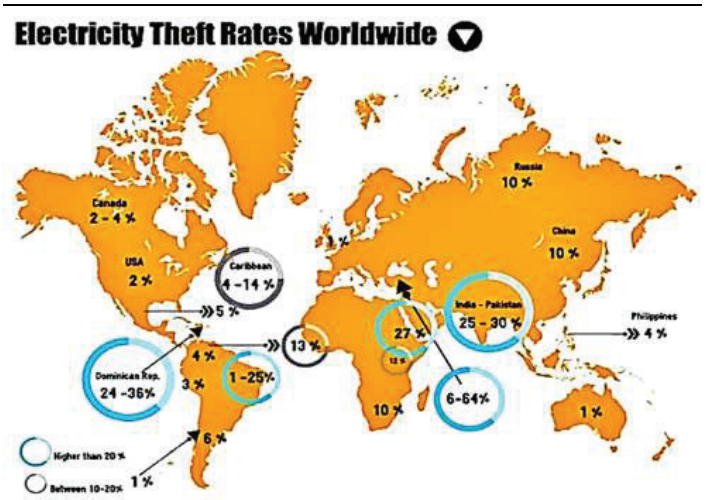

Figure 4: Global access to electricity (2016) [12]

developed and developing countries and seems to suggest that this phenomenon mostly occurs within developing countries.

A SOUTH AFRICAN PERSPECTIVE

A. LOSSES IN SOUTH AFRICA-THE ECONOMIC IMPACT

Eskom, a state-owned enterprise and the largest electricity utility in the sub-Sharan African region, with an estimated generating capacity of 45.5 GW, reports in their integrated report for 2018 that a total of 215.91 TWh net energy was produced and 212.19 TWh sold to its approximately 6.3 million customers. The report further highlights that approximately 21.09TWh was lost which was attributed to technical and other losses and further shows that 496GWh was unaccounted for. From the figures presented then, it is thus deduced that the utility suffered total approximate losses of 21.5 TWh, concluding total approximate losses of 10% of the delivered capacity. The Eskom rate per kWh as reported by Fin24 for 2018, was at 89.13 c/kWh. In highlighting the financial impact suffered by the utility, these losses on average would equate to approximately R19.1 billion annually in real terms or alternatively approximately R54 million rand per day. The significance of these losses highlights financial losses to the South African economy of approximately 0.4% of GDP (Gross Domestic Product) for 2018. These losses, which must be redressed, are then generically mitigated for through tariff increases exposing the already burdened economically active society and businesses to undue further tariff increases. Eskom states that these NTL's are mostly directly attributed to electricity theft and that it is not only contained to *"townships"* and occurs across all sectors of society. The impact of these losses further exacerbates the fact that government now faces increasing difficulty to provide resources from the fiscus to employ allocated infrastructure funds to address backlogs in service delivery.

According to statistics South Africa, 58% of electricity distributed in South Africa is done by Eskom and the remainder 42% delivered by approximately 257 municipalities within South Africa. These municipalities which act as intermediaries between Eskom and the end user generated R22.5 billion in revenue from the sale of electricity between January and March for 2017, and during the first quarter ending June 2018 this figure grew to R24.9 billion, thus an increase of 11% year on year. These municipalities apply higher tariffs to that of Eskom in order to attract profits from the sale of electricity. In fact, municipalities are much more reliant on the sale of electricity as this accounts for the largest part of their

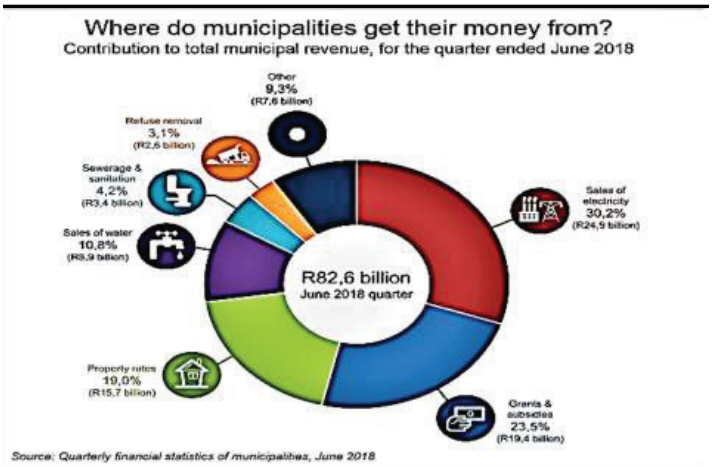

Figure 6: Municipality revenue from electricity sales [22]

budget requirements, which in some cases accounts for than 40% of their budgeted revenue requirements. Figure 6 highlights first quarter revenue collection for municipalities of South Africa.

As these municipalities are highly dependent of the sale of electricity to satisfy budget requirements, so too are they exposed to the proliferation of NTL's in the form of electricity theft and the provision of *Gratis* electricity. *Gratis* electricity *ceteris paribus* will also now contribute to increased NTL as the electrification programs in South Africa are realized. It is argued that improved access to electricity in communities where consumers cannot afford to pay for such services will increase NTL's and will now become the burden of the paying consumer through tariff increases and taxes.

Although municipalities generate substantial revenue form electricity sales (on average 30.2%), the cost of procuring this electricity is also highlighted as the second largest expense (20.6%) next to employee costs (27.2%). With the prevalence on NTL's and the culture of non-payment amongst communities and businesses, these municipalities are currently exposed to defaulting on payments to Eskom, thus also now forced to address significant tariff increases and in so doing just creating further disruptions and constraints to the South African economy. IOL News highlights this where this debt is significant to the South African economy, as the current outstanding debt to Eskom is proportioned at R28 billion, escalating at R1 billion rand a month.

Impact of Non-Technical Losses

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B. CONTRIBUTING FACTORS TO ELECTRCITY THEFT AND NON-PAYMENT

It has been reported in literature that Eskom on average, suffered NTL of approximately 7%, pre-2014. However, Eskom reports, that NTL have been reduced to 6.43% in 2016. Based on the losses presented in the latter, it would then suggest that more than 60% of the total losses suffered by Eskom still amount to values larger than R11 billion annually. The factors contributing to the theft of electricity and the culture on non-payment in South Africa are attributed to the following elements found within this environment. They are, access to electricity, the socio-economic situation, high tariffs and non-payment culture, corruption, poor service delivery and the implementation of legislation. These various elements will be highlighted and unpacked for further discussion below.

According to Statistics South Africa, general household survey for 2018, access to electricity improved from 76.7% in 2002 to 84.7% in 2018. Eskom reports however in an IOL News publication, that access to electricity improved from 36% in 1994 to 90% in 2018. The report further highlights that only 80% of the population living in rural communities currently have access to electricity.

The informal urban settlements which constitutes approximately 10% of the population still presents challenges in terms of the provision of electricity and it is argued that that due to these challenges and the slow pace of delivery, illegal connections are prevalent. Therefore, access to electricity still presents a challenge to utilities and communities and allows the perpetuating of illegally connections to the existing power grid.

The socio-economic situation presents itself as direct consequence of the current high unemployment rates found within South Africa. The current employment rate according to Statistics South Africa is at a record high of 27.6% for 2019, 0.5% higher than indicated in the previous year within the same time period. With the population in dire need of employment, migratory patterns occur between the nine provinces found within South Africa.

Gauteng the smallest province in South Africa produces approximately 35% of the South African GDP, and therefore is perceived as an attractive economic haven. The result of these migratory patterns places severe strain on the current infrastructure and the ability of government to provide access to the basic human right needs of water, sanitation and electricity timeously.

Although the Gauteng and KwaZulu-Natal provinces represent the highest population percentages comparatively, the geographical areas are substantially different, with the Gauteng province approximately 5 times smaller than KZN, and thus the population densities are aggravated. Figure 7 highlights the population densities per province. This situation now present informal settlements developing within the outskirts of the urban areas and as basic services are not available. The population now move to take matters into their own hands to ensure access to electricity by connecting illegally to nearby power grid infrastructure.

High tariffs compound the effect off the NTL as the economically active population start finding it difficult to pay for these services due to affordability. The non-payment culture phenomenon cannot be viewed myopically and in isolation and must therefore be viewed from a collective economic perspective. Due to the current economic situation presented in South Africa the affordability issue is exacerbated by high taxes, population debt levels, food costs, transport costs, just to name a few. It is recorded by statistics South Africa that out of almost 58 million people, only 16.4 million people in the population (working age from 15-64 years old) are employed and that 6.2 million people are unemployed. To indicate the disparity in terms of tax revenue collection from the 16.4 million people that are employed, R1216.5 billion rand was collected for 2018 and grew by 8.7% (R37bn) from the previous year. Personal income tax was the largest component and amounted to 38.1% of the total revenue collected followed by VAT (value added tax) which amounted to 24.5% and further companies' tax of 18.1%.

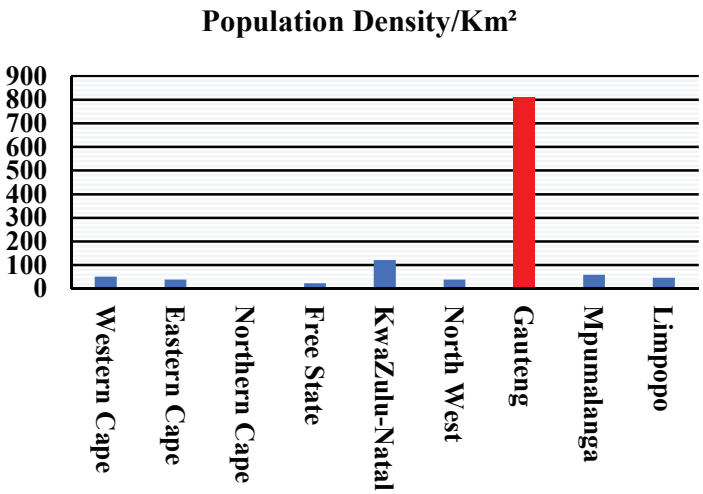

Figure 7: Density population per province [36]

Further statistics presented by the South African Revenue Services, highlights that only approximately 4.9 million people (30% of the working population) was subject to personal income tax.

It is evident from this that almost R465 million was collected from 4.9 million out of a population of 58 million people through taxable income. VAT, on the other hand, affected the population employed and non-employed alike. From this, a clear picture is presented as to the burden the economic pressures places on the population from a taxation perspective, notwithstanding the effect of the population individual debt levels with high interest rates, as well as food and transport costs. This collective economic perspective thus suggests the increased prevalence of electricity theft and a non-payment culture.

Corruption plays a significant part in the poor administration of revenue collection. This is attributed to utility employees who connect electricity for communities illegally for personal financial gain, as well as extort monies from non-paying consumers who have connected illegally to the power grid and who face arrest and prosecution. These illicit actions are highlighted in an exclusive interview presented by an Eye Witness News (EWN) report in 2019, where an Eskom employee revealed that more than half of Eskom employees are part of this connivance.

Poor service delivery is highlighted in a study conducted in KwaXimba KZN, where it was cited that poor service delivery was earmarked as the second largest reason for electricity theft following economic conditions. Poor service delivery also attracts violence, protests and destruction of property as reported by, where illegal connections (done due to poor service delivery) are removed by utilities, therefore rallying the communities into disruptive and dangerous behavior.

Although South African legislation, historically, only covered illegal connections through municipal bylaw's and meter tampering by virtue of fraud convictions, the prosecution rate was not deemed effective enough and therefore allowed these illicit acts to continue. In 2015, South Africa introduced the *"Crime Matters Amendment Act"* (Act 85 of 2015) to address infrastructure crime related incidents as well as to mitigate tampering on the networks. This prosecuting tool has been employed but has had some difficulty in gaining traction in the implementation thereof by the South African Police Services. This is evident from *"Operation Khanyisa"*, an awareness campaign initiated by Eskom in 2010, where it is recorded in 2016 that although *"96% of South Africans knew electricity theft was wrong only 16% believed that they would get caught. A further 14% believed they would get prosecuted if caught"*. This perception clearly highlights the effect current policing and legislation have on the population who partake in these illegal activities.

C. HEALTH, SAFETY AND ENVIROMENTAL IMPACT

South Africa is understood to be the 14th largest emitter of greenhouse gasses (GHG) with an emission per capita benchmarked at 9.5 tonnes of carbon dioxide (CO_2) equivalent (tCO_{2e}). Although this represents less than half of that of the US, it is still well above the world average of $6.8tCO_{2e}$. The reason for South Africa's high emission statistics is due to its reliance on fossil fuels, especially coal to generate electricity. According to statistics South Africa, 88% of its electricity is generated by coal-fired power stations with coal reserves lasting for up to 256 years (as at 2014). The production of electricity using coal is still considered the least cost benefit and will therefore still be used as the primary electricity delivery mechanism for the foreseeable future. Although South Africa have embarked on alternative strategies in the form of renewable energies, more can be done in the reduction of GHG through the reduction of NTL's. It is argued that by reducing NTL's less coal will be burnt and thus reduce the greenhouse gas emissions.

Electricity theft contributes to serious health and safety concerns within communities where these illicit actions occur. The consequences of these actions do not just expose the individuals connecting illegally to electrocution, but more so the innocent community members such as children who are exposed to these illegal connections. In 2016/2017 Eskom reported that at least 50 South African were killed nationwide due to illegal connections with a further 150 others injured. Intervention in mitigating NTL's should therefore be prioritized not just to address the financial benefits in terms of revenue improvement, but due consideration should be afforded to the environmental aspects and more importantly the safety consideration of communities.

D. WHAT CAN TO BE DONE TO AMELIORATE NTL IN SOUTH AFRICA

Deployment of SMART Technologies with intelligent data management algorithms in households and businesses should be the primary implementation strategy to address immediate revenue and cash-flow

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improvement. This will allow for more controlled mechanisms in the detection of NTL's at the customer point of supply (PoS). This strategy however, will still present some challenges to the *"backbone"* electrical infrastructure since SMART technologies deployed in households will only detect theft and tampering at the PoS. Illegal connections detection on the "backbone" infrastructure should therefore then be mitigated by suitable intelligent technologies to detect pilferage on the main infrastructure supply. It is also suggested that in areas where the cost to electrify out ways the revenue generated due consideration should be given to off-grid supply with the aid of renewable energy mini-plants.

Although South Africa employs its *"Universal Access Program"* as part of its Integrated National Electricity Plan (INEP) more should be done to provide access of electricity to all at affordable tariffs. The use of adopted legislation and effective policing to address electricity theft should be based on a zero-tolerance approach and duly promulgated. Consideration should be afforded to the input costs (i.e. NTL) in the establishment of electricity tariffs and it is argued that NERSA should implement strategies to hold Eskom and municipalities accountable for the management of NTL's.

COMPARITIVE ANALYSIS

Table I is provided for comparative representation. Recorded NTL's for South Africa are benchmarked at approximately 7% annually, which in financial terms translates to approximately $95 million. Compared to global trends this represent approximately 0.1% of overall global NTL's, however, still represents a significant impact on the South African economy. Global access to electricity as highlighted by World Bank statistics is defined as 88% for 2015, and that of South Africa highlighted to be 84.7% for 2018. Electricity theft in South Africa is recorded to be in the order of 10%.

From a global perspective the average electricity theft statistics are difficult to quantify due its heterogeneous nature. However, with South Africa representing 10% on average in comparison to developed countries (where NTL are between 1 and 5%) and in developing countries (where it can be as much as 50%) still seems to suggest that the figure presented is considered above the accepted norm. The global GDP as cited by KNOEMA was in the order of $84.8 trillion for 2018.

With recorded global financial losses at approximately $96 billion, the global percentage loss of GDP yielded 0.113% and in comparison, the South African ratio translates into 0.4%, higher than the global norm. With a global population of 7.7 billion people, and the global financial losses at approximately $96 billion, the financial loss per capita is calculated based on the fraction of financial losses to the respective population data and highlights that South Africa presents statistics of approximately 13% compared to that of global trends.

This suggest that financial losses suffered in South Africa because of NTL are significant in the comparative context. The percentage of NTL as compared to the overall losses in the South African context is tabled at approximately 7%, however the comparative losses from a global perspective (i.e.1.4 TkWh out of 20 TkWh) represent on average 7%. This seems to suggest that South Africa is on par with the global trend. Finally, the significance of the South African fossil-fuel electricity production policy is highlighted in the tonnes per CO_2 equivalent.

The South African statistics are recorded as 9.5 tCO_{2e} compared to the global trend of 6.8 tCO_{2e}. This highlights the environmental concern South Africa is faced compared to global trends. This comparative data suggest that South Africa is approximately 40% higher in CO_2 emissions as a direct consequence of electricity generation by virtue of coal-fired power stations.

CONCLUSION

Total losses suffered by the South African economy in terms of generated electricity supply is in the order of 10%. This translates into approximately $1.4 billion in revenue losses annually compared to approximate world losses of $96 billion. These losses of $1.4 billion reflect approximately 0.4% of the South African GDP compared to 0.113% of world GDP losses and suggests a ratio of 3.5 times higher than global GDP.

Item	South Africa	Global
Financial Losses (NTL)	≈ $95m	≈ $96bn
Access to Electricity	84.7%	88%
% Electricity Theft	10%	≈ 1 to 50%
% Losses to GDP (USD)	0.4%	0.113%
NTL Financial Losses per Capita (USD)	≈ 1.66	≈ 12.5
% NTL of Total Losses	≈ 7%	≈ 7%
%CO2 Emissions	9.5tCO2e	6.8tCO2e

Table 1 - Comparative Table

South African non-technical losses (as part of the overall loss equation) represents 7% of the total losses and in real revenue terms highlights these losses to be in approximately $95 million (R1.4bn) annually.

Access to electricity in South Africa is benchmarked at almost 85%, still presenting a challenge in rural communities, however the largest catalyst for electricity theft is related to affordability and lends to economic migration patterns where the population migrates between provinces to seek employment, and therefore informal household dwellings are realized, perpetuating illegal connections and electricity theft. In an ailing economy with high tax burdens, high fuel costs, high electricity tariffs and a high unemployment rate the culture of electricity theft and non-payment is prevalent. These illicit actions further compound the problem in terms of health and safety in communities and greenhouse gas emissions for the country.

It is therefore imperative that South Africa address this problem as a matter of urgency. The accomplishment of the mitigating strategy should address a collective outlook on how electricity is generated, distributed and sold to the end user.

As part of the strategy legislation and the implementation thereof needs to be enforced with a zero-tolerance approach to create a law-abiding culture, which is currently lacking. Furthermore, the strategy must include job creation and the timeous completion of affordable electricity access to all, with the provision of improving the policy on "Free Basic Electricity" and address non-technical system losses through innovative means in order to reduce the cost of producing electricity, therefore improving tariffs to the consumer.

It is suggested that the South African electricity regulator (NERSA) consider more stringent mechanisms for non-technical loss mitigation, which might include punitive and reward programs for loss management improvement. wn

REFERENCES

For details, please email minx@saiee.org.za

Stirling Megawatts

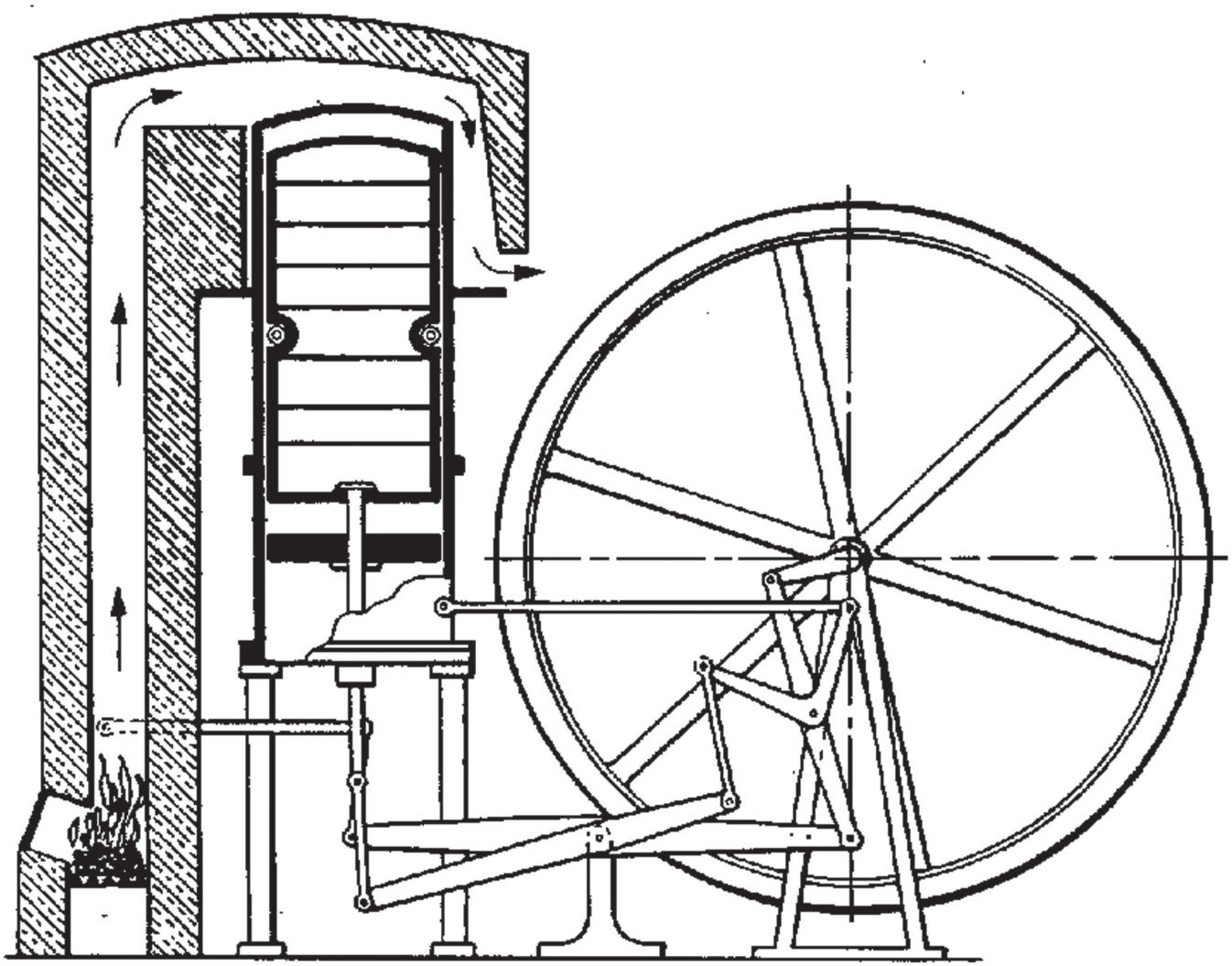
Scottish clergyman the Rev. Robert Stirling (1790-1878), developed and patented his remarkable air engine, with the assistance of his brother James, an engineer, in 1816.

BY DUDLEY BASSON

This efficient heat engine had air as an enclosed thermodynamic fluid. In modern Stirling engines, hydrogen is regarded as the best gas for this purpose. Heat is applied externally which can be from any convenient heat source. The engine usually has either two cylinders with pistons (Alpha type) or one cylinder with two pistons (Beta type). Other versions with multiple cylinders are also possible. In the beta version the hot (displacer) piston does not seal the cylinder but allows the gas to pass between the hot and cold cylinders. Efficiency is improved by providing a regenerator (economiser) connecting the cylinders.

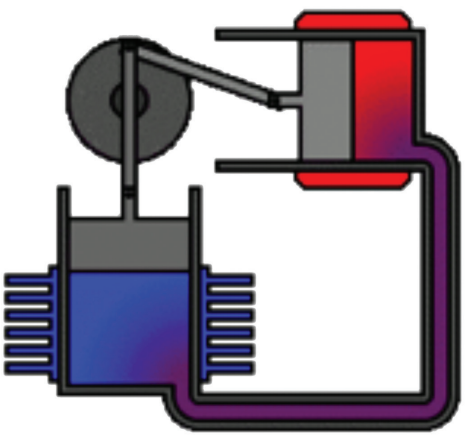
The Stirling engine is remarkable in its simplicity without any valves, and its quiet operation. The Stirling engine is a closed-cycle regenerative heat engine with a permanently gaseous working fluid. The theoretical basis of this engine would not be well understood until the work of Sadi Carnot. The Carnot cycle is an idealised four process thermodynamic cycle with the highest possible thermodynamic efficiency, which depends only on the source and sink temperatures. The Carnot cycle is not suited to practical application as its operation would be too slow. The Stirling engine can operate at an efficiency close to that of the Carnot cycle. This engine does not readily lend itself to analysis of discrete thermodynamic processes and designing the engine is complex with some interdependencies and requires practical prototyping. The operation of the engine depends only on a temperature difference between the hot and cold cylinders, which can be as little as 2°C in demonstration models. Efficiency can be further improved by using air warmed by cooling the cold cylinder to pre-heat the air used in combustion to heat the hot cylinder. The engine can also operate by refrigerating the cold cylinder with or without heating the hot cylinder, and when operated in reverse, it can also act as a heat pump. The output of the engine can be increased by pressurising the working gas. The engine is well suited to working with a low temperature differential. It can happily work using hot geothermal water and can also benefit from using water cooled by ice or snow if available.

The Stirling engine has remained neglected for more than two centuries. Its low power to weight ratio and limited size meant that it was not suited to vehicular use and in industrial situations it could not compete with steam engines or later, with electric motors and internal combustion engines. Stirling engines have taken a leap into the future, being use for powering spacecraft in the outer Solar System. The engines are heated by a plutonium isotope and can give three times the power obtainable from thermocouples reducing the quantity of plutonium required. These engines are able



The original patent Stirling engine of Rev. Robert Stirling.

to function continuously for several years. Stirling engines usually have a power output of less than 50 kW, however several engines can be combined on a common crankshaft to utilise a single, larger and more economical alternator. This would also simplify engine balancing and reduce the flywheel requirement. In this case it would be simpler to use separate crankshafts for the hot and cold pistons. The hot and cold pistons are normally set at 90° out of phase. With separate crankshafts linked by means of differential gears, the phase angle could be dynamically experimentally adjusted in order to obtain the optimum phase angle. There is no practical limit to the size of the engines but size and speed are limited if the heat and cooling are applied directly to the



Alpha type with two cylinders. The pistons of the hot (red) cylinder and the cod (blue) cylinder are 90˚ out of phase on the crankshaft. The regenerator connecting the cylinders improves efficiency by cooling the gas as it moves to the cold cylinder and heating it as it returns to the hot cylinder.

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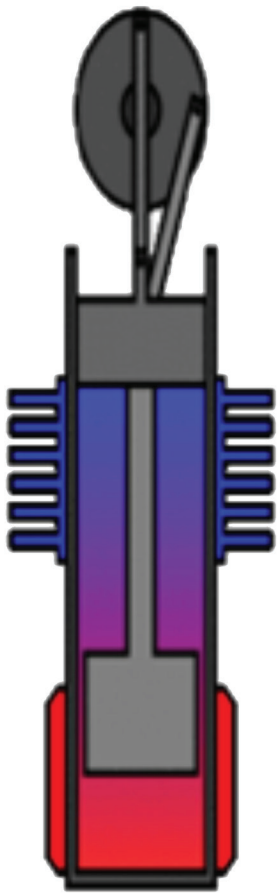


Beta type with one cylinder. The displacer piston does not make contact with the cylinder and requires no lubrication. The power strokes are provided by the cold piston. The renegerator function is provided by the displacer piston and cylinder walls.

cylinders which give limited heat transfer area. With the alpha type, heat transfer can be greatly increased by using heat exchangers with clusters of small bore metal tubing at the cylinder ports. Performance and efficiency can also be improved by using an insulated regenerator consisting of a large cluster of small bore metal tubing. Regenerators can also be made from steel wool or other porous material.

The Stirling engine may see a major revival as it is well suited to power generation from concentrated solar power or combustion of biomass, gas or other waste material and can conveniently use heat from molten salt storage.

A new type of heat energy storage has been inaugurated at DTU Risoe, Denmark. Instead of molten salt, the energy is stored in spherical steel capsules filled with stones which are heated to 600°C. These can be heated either directly by CSP or biomass, or by electric heaters powered by PV or wind turbines.

The test site headed by SEAS-NVE hopes to develop a method for large scale energy storage solutions. The 3,5 m^3 test facility is able to store 875 kWh. A target goal is to develop a 2,5 GWh facility.

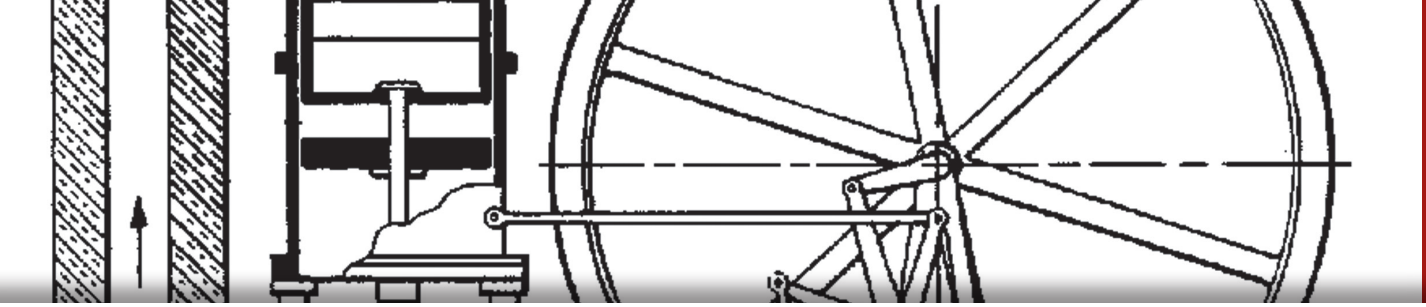
NIRAS as a consultant for SEAS-NVE, coordinated the numerous ideas for design and prepared a final storage prototype, which can be scaled and complies with the technical requirements made for the final product.

A major advance in the use of Stirling technology is being made by the South African ferrochrome industry. A huge enterprise is underway to utilise Stirling engines for generating electrical power from industrial off-gas. This power will be generated without any additional CO_2 emission as the gas would otherwise have had to be flared. A huge reduction of CO_2 emission will be achieved by using less electrical energy from the coal burning utility. This project will utilise containerised Stirling engines supplied by a leading Swedish manufacturer. These superb products are the result of modern R&D, and utilise newly patented features. Each container houses 14 Stirling sets with a combined output of 400 kW. Glencore's Lydenburg smelter will utilise 25 containers to supply 10 MW. The Krugersdorp plant will have 2,8 MW capacity. South Africa has globally the highest concentration of ferrochrome producers with a total off-gas power output of 200 MW.

For the agricultural scene, the Stirling engine offers attractive mix-and-match possibilities.

If biomass is to be used, the engine will require a furnace with ducting and blowers as well as a biomass handling facility. A concentrating solar collector could also be used to increase power availability if the biomass is not continuously available. The solar power could be collected by either a single axis tracking trough or a two axis tracking dish. The continuity of power availability could be further improved by adding a molten salt heat storage tank to the mix, which can buffer fluctuations caused by intermittent cloudy weather. With salt heat storage in place, the engine could be driven by heat from the salt and the heat sources used to heat the salt. Molten salt heat storage has a comparable specific energy to that of lithium-ion batteries.

Sugar cane tops and leaves represent a huge source of combustible biomass which is usually burned to waste. The energy in sugar cane is in roughly three equal parts: The juice which is used to produce sugar or ethanol; the bagasse (crushed stalks); and the trash (leaves and tops). Using the combustible biomass to produce electric power could do much to boost the profitability of the ailing R14 billion industry.



If biomass is to be used as the heat source, special consideration must be given to the design of the furnace. In order to obtain a high thermal efficiency, it is necessary to operate at high temperatures, possibly up to 1000°C. Working at high temperature can cause the build-up of slag on the heat exchangers necessitating automatic removal.

Working at high temperature may well require the use of ceramic pistons and cylinders in the Stirling engine. Stirling engines can easily run at a speed of 1500 r.p.m. which would be the synchronous speed for driving a 4-pole alternator.

A large biomass Stirling plant has recently been commissioned at a spa and wellness centre in Germany by a Danish energy system provider.

This four engine Stirling plant is fuelled with wood chips locally sourced, and will deliver 4 GWh of heat and 1 GWh of electricity annually to the spa at Tabbs in Tabarz, Thuringia.

The project was implemented as a joint partnership with the Siemens Building Technologies Division office in Leipzig, a local partner and Stirling.DK as equipment manufacturer.

Stirling.DK's CEO Dr. Lars Jagd commented: *"We are very proud to hand over this state-of-the-art combined heat and power plant based on Stirling engines fuelled with biomass for this truly trend-setting application. The plant is a landmark achievement and represents a significant technological breakthrough within onsite renewable energy generation and will secure the spa a leading position with regard to sustainability."*

See the following video for an excellent description of the working of the Stirling engine:
https://www.youtube.com/watch?v=Qshc2yWKq2A

See the following video for a 16 cylinder Stirling engine running at nearly 2000 r.p.m.
https://www.youtube.com/watch?v=nSE3GmUdxoQ

See the following video showing the working of alpha, beta and gamma engines:
https://www.youtube.com/watch?v=gQb2sN6UWkA

For a 4-cylinder engine driving a generator see:
https://www.youtube.com/watch?v=36T3i6S5zSc

See how to make a Stirling engine from beverage cans, wire and glue at:
https://www.youtube.com/watch?v=5m09CJFdERc

In this model, steel wool is used for the displacer piston, which also performs the function of the regenerator. The cold piston is dispensed with by using a latex diaphragm which serves the same purpose.

An interesting variant of Stirling power is to use an engine with free floating piston driving a linear reciprocating alternator.

For info on the magnetic circuits of the linear alternator's plunger and stator see: https://pdfs.semanticscholar.org/c711/b2e3c5ea78a8d40f693064e8f44b65646d9d.pdf

For an excellent and highly detailed account (must read) of the history and development of Stirling engines, refer to the MSc thesis submitted by Caleb C Lloyd to the University of Canterbury, New Zealand in 2009:
https://core.ac.uk/download/pdf/35461393.pdf

For the World Economic Forum report on global energy transition see:
https://www.weforum.org/agenda/2019/03/the-countries-most-ready-for-the-global-energy-transition

100 square metre Swedish Stirling-CSP dishes being tested in the Kalahari. These units have two axis tracking and 30 kW output and have set a new world record of 34% solar to electricity efficiency.

China has embarked on building Stirling CSP plants, totalling 200 MW capacity, to be built by Sweden's Cleanergy AB and China's Datang Holdings. The first batch of CSP tower, parabolic trough and linear Fresnel plants has been concentrated in the provinces of Qinghai, Gansu and Xinjiang in Western China and Hebei and Inner Mongolia. The partners went ahead with the construction of a 50 MW CSP plant by 2018 followed by a 150 MW plant including energy storage. There are plans to build CSP plants of 1,3 GW capacity.

Stirling Megawatts

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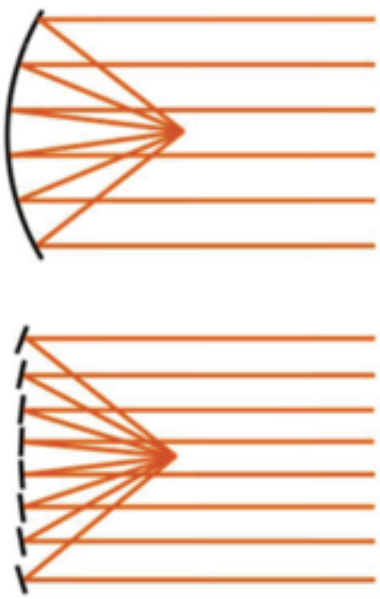
100 square metre Swedish Stirling-CSP dishes being tested in the Kalahari.

Wang Xu, Director of Datang declared:
"Our goal is to make the Stirling solar application dominant in China for new energy and manage to get its cost level competitive by localization.

Cleanergy and Datang are now jointly producing a project feasibility report to realize the full cost reduction potential by localizing production in China, starting with component sourcing and assembly of the dish concentrator."

Jonas Eklind, CEO of Cleanergy AB commented:
"China is an important market for Cleanergy with a potential of 10 GW installed solar energy with storage by 2030. We have been present in the region since 2010 and the first to come this far with Stirling CSP. There is no doubt that there is currently an extremely strong momentum in the solar energy market, in particular solar energy in combination with energy storage. A historical transition is taking place where solar energy, for the first time, is becoming the cheapest form of energy. Those players who possess a strong technology today for production and storage will be the winners and dominate the market now and in the future."

The Stirling engine, which has for two centuries been little more than a curiosity, is now ready to take its place on a global scale as a major player in clean renewable energy and to help reduce CO_2 emission and global warming. wn



Parabolic trough reflector compared to linear Fresnel reflector.

MORE SPARKLING ACHIEVEMENTS

NEW BOOK TO BE PUBLISHED SOON!

Highlights of Electrical Engineering Into the 21st Century from 2001

In October 2001 the **South African Institute of Electrical Engineers** published a coffee table book titled ***SPARKLING ACHIEVEMENTS.*** This highly successful volume was sponsored by **43** local companies and comprised **180** advertorial pages highlighting the achievements of these organisations from inception up to the year 2000.

The following list shows the number of pages sponsored by each organisation, in a range from 1 to 10 pages per sponsor: ***(In alphabetical order)***

ABB Holdings **4**
ABB Powertech Transformers **3**
ATC **5**
Aberdare Cables **4**
Alcatel Altech Telecoms **5**
Allied Technologies **1**
Alstom South Africa **7**
Altech Card Solutions **1**
Anglo Technical Division **4**
Arrow Altech Distribution **1**
CSIR **5**
Circuit Breakers Industries **1**
Conlog **2**
Energy Measurements **2**
Eskom **3**
General Electric South Africa **1**
Marconi Communications SA **4**
Merlin Gerin SA **2**
M-Net **10**
MTN Mobile Telephone Nets **10**
Multichoice Africa **2**
National Data Systems **4**
Orbicom **3**
Potchefstroom University **2**
Rand Afrikaans University **2**
Reunert **2**
Richards Bay Minerals **2**
Rotek Engineering **6**
SABC **5**
Sentech **3**
Siemens South Africa **2**
Spescom **2**
Spoornet **8**
Stellenbosch University **2**
Strike Technologies **2**
Telkom **3**
Transtel **2**
UEC Technologies **1**
University of Cape Town **1**
University of Natal **5**
University of Pretoria **4**
University of the Witwatersrand **4**
Vodacom Group **8**

The second edition *MORE SPARKLING ACHIEVEMENTS* will include the following areas of electrical engineering activity:

Electrical Research Technology
Development and Standards
Telecommunications
Electrical Power and Distribution
Electrical Traction
Broadcasting
Information Technology
Mining
Radio Astronomy
RADAR
Medical electronics
Satellite technology

The cost of each page of advertorial will be R2000 and two books will be given free of charge, to each sponsoring company, for each group of four sponsored pages or part thereof. It is suggested that these books be placed in the company reception and CEO's office. The book will be advertised to the Institute's 6000 members and copies will be available at R350 each. The book is ideal to present to VIP visitors to this country who wish to learn about this country and what it has achieved.

We expect school and University libraries will value the book as an indication to students of what the profession of electrical engineering is all about. The new book will match the size of the first edition (240x320mm) and will consist of between 170 and 180 full colour high quality pages.

SAIEE

Our Expert Answers

Information provided by Zest WEG Group

QUESTION ONE

With globalisation becoming more prevalent today there is a need for electric motors to work in different locations around the world. Can my 50Hz electric motor operate when connected to a 60Hz network supply?

ANSWER ONE

The answer is yes. Three phase motors wound for 50Hz can also be connected to a 60Hz network. By connecting a 50Hz motor, of the same voltage, to a 60Hz network, the motor performance will be as follows:

- Same output
- Same rated current
- Starting current decreases by 17%
- Starting torque decreases 17%
- Breakdown torque decreases 17%
- Rated speed increases 20%

If the voltage changes proportionally to the frequency, i.e. consider the example of 400V 50Hz = 480V 60Hz, then the motor performance will be as follows:

- Motor output increases 20%
- Rated current is the same
- Starting current will be approximately the same
- Starting torque will be approximately the same
- Breakdown torque will be approximately the same
- Rated speed increases 20%

QUESTION TWO

How does altitude affect an electric motor's performance, and can my electric motor rated for 1000 m.a.s.l. operate at 1500 m.a.s.l.?

ANSWER TWO

With increasing altitudes comes atmospheric air that is thinner and less dense. This means that in a TEFC configuration there is a lower volume of air being transferred over the motor frame for cooling.

When using a standard, rated for 1000 m.a.s.l. there are a few options one can consider:

- The absorbed power is limited the calculated derating factor. For example, at 1500 m.a.s.l. the derating factor on an electric motor is 3%, hence a 45kW motor rated at 1000 m.a.s.l. will be rated for 43.65kW at 1500 m.a.s.l..

- If the motor carries a service factor greater than 1 this means that the value above 1 represents the allowable load that can be applied to the motor, in percentile. The load can be applied continuously under specified operating conditions or continuous overload conditions. The value over 1 represents the power reserve that gives the motor a greater capacity to withstand adverse operating conditions. For example, a 45kW motor with a service factor of 1.15 means that 51.75kW load can be applied to the motor shaft continuously.

QUESTION THREE

What are the concerns when replacing an old slipring motor with a squirrel cage motor with a variable speed drive, and are there any benefits?

ANSWER THREE

Currently there are thousands of applications running with old slipring motors that are reaching the end of their lifespan. Slipring motors were commonly used for high torque applications considering that a slipring motor is able to deliver its breakdown torque at start up.

There is a common misconception that squirrel cage motors do not have high starting torques or that the old slipring motor must be replaced with another slipring motor.

With technology ever advancing, high efficiency squirrel cage motors produce sufficient torque, in most cases, so a slipring motor can be replaced with a squirrel cage motor and variable speed drive like for like in kW size.

Some of the advantages of replacing slipring motors with squirrel cage motors include readily available stock in low voltage configuration, much lower capital cost and more flexibility of process control and energy savings with the variable speed drive. Squirrel cage motors are also much easier to maintain and there is no need to be concerned with replacing brushes.

QUESTION FOUR

Vibration is one of the most common causes of failures on electric motors and many people often ask what the acceptable vibration levels on electric motors are.

ANSWER FOUR

The vibration limits on electric motors are defined as per IEC standard 34-14

and Nema MG1 part 7. Vibration measurements are generally performed on the non-drive end and drive-end bearing planes, viz. vertically, horizontally and axially.

Electric motors should be factory balanced with a half key and the below values give a generic guideline for compliance.

Rated Speed: n (rpm)	**Vibration Levels (mm/s rms)**			
	Frame	< 355	630	>630
600 ≤ n ≤ 1800	Alarm	4.5	4.5	5.5
	Trip	7.0	7.0	8.0
1800 < n ≤ 3600	Alarm	3.5	4.5	5.5
	Trip	5.5	6.5	7.5

Some of the causes of vibration most frequently identified in the field are misalignment between the motor and the driven load, incorrect fastening of the motor to its base, improper base construction and also external vibration caused by other equipment. Vibration sensors, therefore, form part of the set-up of critical applications. Operating electric motors with vibration values above those specified in the table above can significantly damage the motor and create a reduced lifespan and/or motor performance.

October in History

October is the tenth month of the year in the Julian and Gregorian Calendars and the sixth of seven months to have a length of 31 days.

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

1 OCTOBER

2008 A Metrolink engineer, at the helm of a commuter train in Los Angeles, California, USA, was found to have been text messaging seconds before colliding with a freight train. 25 people were killed in the accident and numerous others were injured.

2 OCTOBER

2009 The 2016 Summer Olympics are awarded to Rio de Janeiro in Brazil.

3 OCTOBER

1952 Tea rationing ended after 12 years in Great Britain, a nation of tea drinkers. Sweets, meat, eggs, butter and sugar were still on ration.

4 OCTOBER

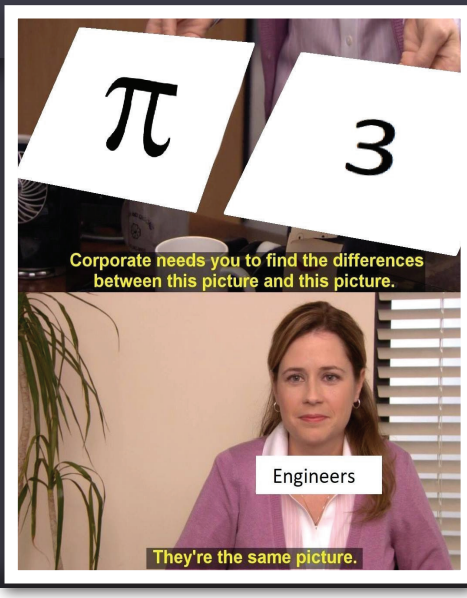
1979 Hewlett Packard came out with their first Programmable calculator in 1979. The HP-41c was the first to give alphanumeric display capabilities. It would actually tell you what to do (ex. "ENTER RADIUS") instead of leaving you wondering. It also had four ports that could be used to expand memory, install a Thermal printer, magnetic reader or bar code scanner.

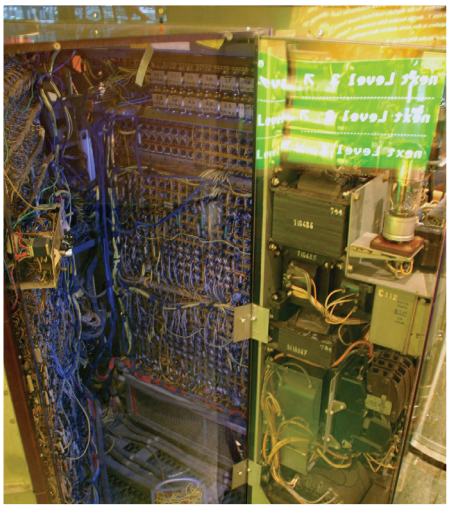
5 OCTOBER

2016 It was announced that The Paris Agreement on Climate Change, which governs greenhouse gas emissions, would take effect in November.

6 OCTOBER

1954 IBM researchers modified an existing model 604 vacuum tube calculator to use transistors. This experiment didn't shrink the desk-sized machine nor make it any faster, but it did use only 5% of the power the vacuum tube-based design did.





7 OCTOBER

1959 The Soviet spacecraft Luna 3 took pictures of the far side of the Moon. The images sent by the probe covered about 70% of the far side of Earth's natural satellite and they were instrumental in helping astronomers make the first atlas of the dark side of the Moon.

8 OCTOBER

1919 The World's first transcontinental air race began in the USA. 63 aeroplanes took part in this 8690 kilometre round-trip race. The winner, Lieutenant Belvin Maynard, took 3 days and 21 hours to return to New York.

9 OCTOBER

1858 Gerard Leonard Frederik Philips was born. He was a Dutch industrialist and co-founder, with his father Frederik Philips, of Philips as a family business in 1891 in Eindhoven.

10 OCTOBER

1971 After being removed from over the River Thames in London and shipped all the way to Arizona, and then reconstructed, the London Bridge reopened in Lake Havasu City, Arizona, US.

11 OCTOBER

1984 Kathryn Dwyer Sullivan undertook a 3.5-hour long space walk with fellow astronaut David Leestma while on the Space Shuttle Challenger mission STS-41-G. The spacewalk was performed to demonstrate the possibility of refuelling a satellite. STS-41-G was the first flight mission to carry two women astronauts - Sullivan and Sally Ride.

12 OCTOBER

1881 Six 2000 candle-power "Brush" arc lamps were strung up to the dome of the Cape Town Railway Station. The Cape Argus of 13 October 1881 reported: *"The Railway Station was thronged with citizens of both sexes, curious to witness the illumination of the building for the first time with the electric light".*

13 OCTOBER

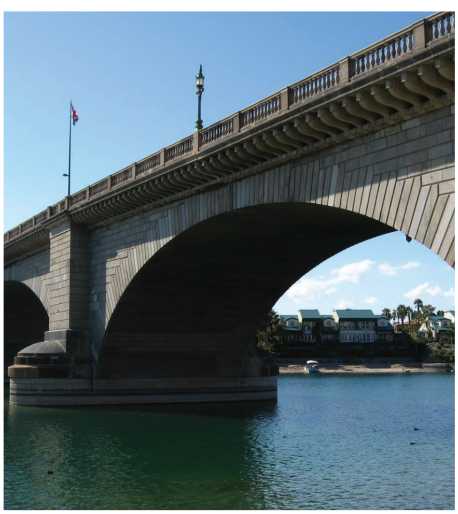
2006 Bangladeshi economist Muhammad Yunus and the Grameen Bank he founded won the Nobel Peace Prize for their pioneering use of tiny, seemingly insignificant loans, microcredit, to lift millions out of poverty.

14 OCTOBER

2004 The Soyuz TMA-5 (No. 215) spacecraft, carrying a crew of three, blasted off from Baikonur Cosmodrome's Site 1, at 07:06 Moscow Time. Onboard were Commander Leroy Chiao, a NASA astronaut, Russian Flight Engineer Salizhan Sharipov and Test Cosmonaut Yuri Shargin, representing Russian Space Forces. Expedition 10 was scheduled to live and work on the ISS for six months.

15 OCTOBER

1997 The Nobel Prize in Physics was awarded to Steven Chu of Stanford, William D. Phillips of the National Institute of Standards and Technology, USA, and Claude Cohen-Tannoudji of the France. Their work centred on slowing the speed of gaseous atoms using lasers. The Nobel Prize in Chemistry was awarded to Paul D. Boyer of UCLA, John E. Walker of Britain, and Jens C. Skou of Denmark for work on how ATP works to store energy in living cells. Adenosine triphosphate (ATP) is the primary energy storage molecule used to activate the reactions needed for growth and reproduction by all living organisms.



October in History

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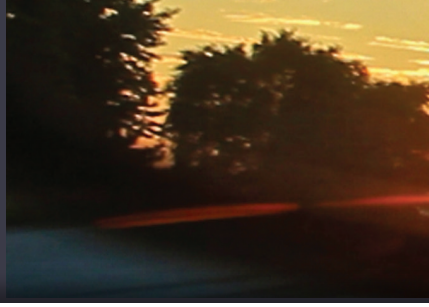


16 OCTOBER

2006 SAIEE's **watt**now magazine was launched.

17 OCTOBER

1906 The Victoria Falls Power Company Limited (VFP) was established. The intension was to supply electrical power in South Africa and Rhodesia [now Zimbabwe] and to acquire the concessional rights to develop the potential of the Victoria Falls. This was estimated to be 250 000 horsepower [190 MW] at minimum flow of the river.

18 OCTOBER

1948 Ntozake Shange was born. She was an American playwright and poet. As a Black feminist, she addressed issues relating to race and Black power in much of her work. She is best known for her Obie Award-winning play, For Coloured Girls Who Have Considered Suicide / When the Rainbow Is Enuf.

19 OCTOBER

1998 In Miami, USA, the first class-action lawsuit brought by smokers against the tobacco industry went to trial. Jurors would eventually find the America's largest cigarette makers and industry groups had produced a defective and deadly product.

20 OCTOBER

1973 The Sydney Opera House was formally opened by Queen Elizabeth II on 20 October 1973. A large crowd attended although the architect, Jørn Utzon was not invited to the ceremony, nor was his name mentioned. Construction had begun before Utzon had completed the blueprints or even figured out how to support the weight of the enormous spherical shells. Utzon famously began work (March 1959) under the consideration that it would take 18 months to develop the design documents for the project, which would ultimately be completed nearly 15 years later.

21 OCTOBER

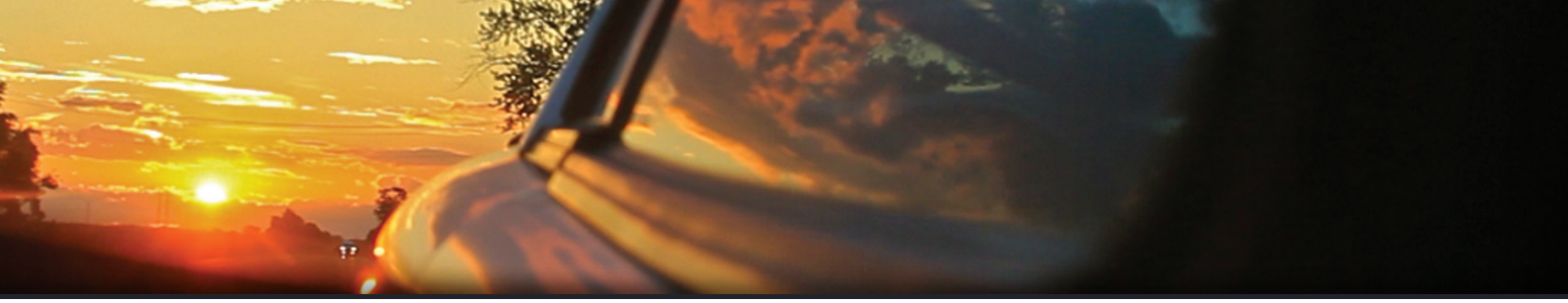
1833 Alfred Bernhard Nobel was born. The Swedish-born chemist, engineer and industrialist who invented dynamite, later established the prestigious Nobel prizes to honour the world's greatest scientists, writers and peacemakers.

22 OCTOBER

2013 Apple announced the introduction of iPad Air as well as the launching of the newest version of OS X, Mavericks.

23 OCTOBER

1814 London surgeon and anatomist Joseph Constantine Carpue performed what is considered to be the world's first modern plastic surgery operation on a British military officer in the Duke of York Hospital in Chelsea, England. During the surgery he reconstructed the patient's nose.



24 OCTOBER

2004 Golden Resources Shopping Mall, or Jin Yuan, a very large shopping mall located near the northwest Fourth Ring Road in Beijing, People's Republic of China, opened for business. At this time, it was the largest mall in the world in terms of gross leasable area.

25 OCTOBER

1956 TAT-1 (Transatlantic No. 1), the first transatlantic telephone cable system, officially went into service with a three-way ceremonial call between New York, Ottawa and London.

26 OCTOBER

1965 The four members of British rock band The Beatles were awarded Member of the Most Excellent Order of the British Empire (MBE) medals at Buckingham Palace, London, United Kingdom.

27 OCTOBER

1938 DuPont announced that they had developed the "first man-made organic textile fibre" which was derived from "coal, water and air" and promised to be "as strong as steel, as fine as the spider's web."

28 OCTOBER

1998 In South Africa the 3,500 page report of the Truth and Reconciliation Committee was formally handed over from Desmond Tutu to President Mandela. It was based on years of testimony from the people who ran the 1960-1994 white-government and their victims.

29 OCTOBER

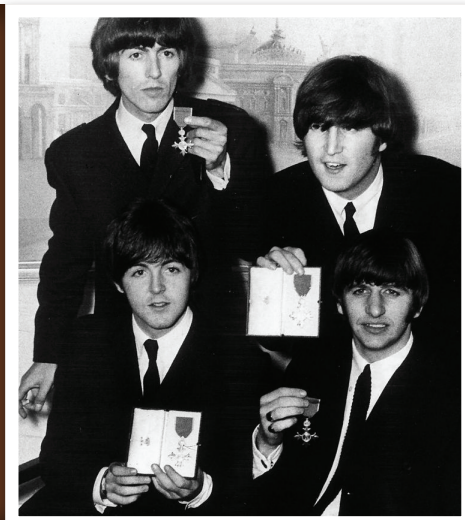
1969 At the University of California, Los Angeles (UCLA) campus, the first message was sent over ARPANET, the forerunner of the internet. Leonard Kleinrock would note later, *"History now records how clever we were to send such a prophetic first message, namely 'Lo'"*.

30 OCTOBER

952 Dr. Albert Schweitzer (b.1875) was awarded the Nobel Peace Prize but only received it in 1953. Schweitzer and his wife Hélène had moved to Gabon (French Equatorial Africa) in 1913 and opened a hospital in Lambaréné, which he later expanded with money from the Nobel Peace Prize.

31 OCTOBER

2019 The United Kingdom's membership of the European Union is expected to cease in accordance with Article 50 following the outcome of their EU membership referendum on 23rd June 2016 after being delayed twice from 29th March and 12th April 2019. wn



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SAIEE
South African Institute of Electrical Engineers

110 YEARS 1909-2019 SAIEE

MEMBERSHIP FEES EFFECTIVE 1 DECEMBER 2019

The Council meeting held on 4 October 2019 approved subscription & entrance fees as from 01 December 2019 as per schedule indicated below.

PLEASE NOTE: In terms of Bylaw 3.2 annual subscriptions are due on 1st December 2019

MEMBERSHIP FEES CAN BE PAID IN MONTHLY RECURRING PAYMENTS

Council agreed to a discount for fees paid before 31 March 2020. Members are therefore encouraged to pay promptly to minimize increase.

Grade of Membership	Annual Subscriptions paid before 31 March 2020		Annual Subscriptions paid after 31 March 2020		New Members FEES * see Notes 1 & 4 below.	
	RSA incl VAT (R)	Outside RSA excl VAT (R)	RSA incl VAT (R)	Outside RSA excl VAT (R)	RSA incl VAT (R)	Outside RSA excl VAT (R)
Student	144	125	173	150	173	150
After 6 yrs study	1 495	1 038	1 794	1 246	1 794	1 246
Associate	1 495	1 038	1 794	1 246	1 794	1 246
Member	1 652	1 147	1 983	1 377	1 983	1 377
after 6 years	1 931	1 340	2 317	1 608	2 317	1 608
after 10 years	2 021	1 402	2 425	1 682	2 425	1 682
Senior Member	2 021	1 402	2 425	1 682	2 425	1 682
after 6yrs/age 40	2 190	1 519	2 628	1 823	2 628	1 823
Fellow	2 190	1 519	2 628	1 823	2 628	1 823
Retired Member (By-law B3.7.1)	929	643	1 115	772	n/a	n/a
Retired Member (By-law B3.7.3)	nil	nil	nil	nil	n/a	n/a

1. The fee for all new applications is R2911.00 which includes an entrance fee of R928.00. On election to the applicable grade of membership the new member's account will be adjusted accordingly and refunds/additional payment made on request. Entrance fee for Students is free and new Student applicants require payment of R173.00.

2. Transfer fee to a higher grade is R504.00 for all grades of membership (except Student within 3 months of qualifying).

3. Members are encouraged to transfer to a higher grade when they qualify. It will be noted that the fees of Member and Senior Member grades after 10 and 6 years respectively are equal to the fees at the next higher grade.

4. Members elected after May 2020 pay a reduced subscription fee.

By-law B3.7.1 reads "Where a member in the age group of 55 to 70 years has retired from substantive employment in the engineering profession, such member may make written application to Council for recognition as a retired person and a reduced membership fee".

By-law B3.7.3 reads "any member complying with the conditions of B3.7.1 but who has been a member of the Institute for not less than 25 consecutive years, shall be exempt from the payment of further subscriptions." Members who comply with the requirements of By-Law B3.7.3 may make written application to Council for exemption from paying subscriptions".

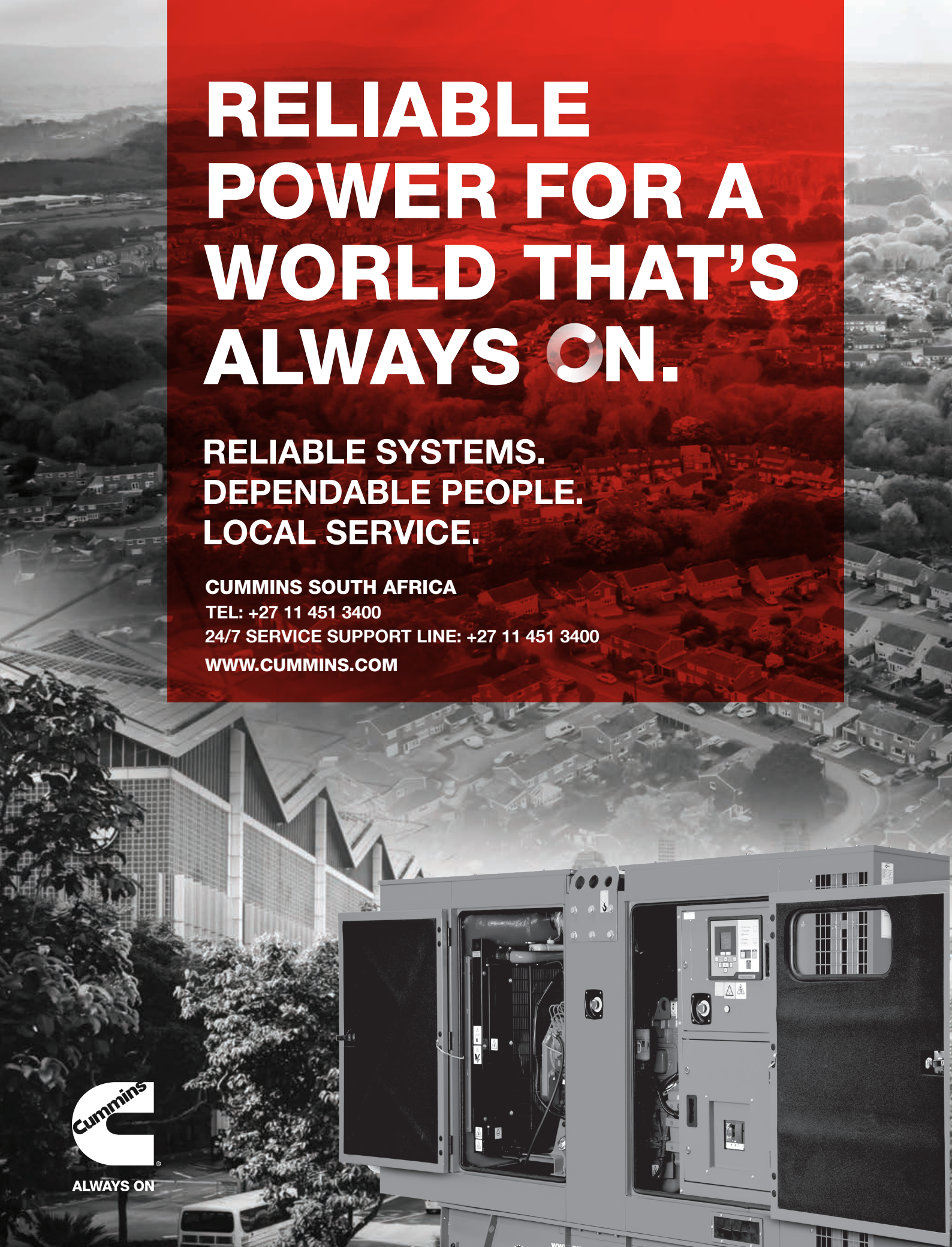
By-law B3.9 reads "any member in good standing who has been a member for fifty (50) consecutive years shall be exempt from the payment of further subscriptions."

Members not in good standing by failing to pay their subscriptions by end of June of each year will, subject to Council decree, be struck-off the SAIEE membership role.

Members in good standing and no longer in substantive employment and do not receive payment or salary for work done may apply to Council for a reduction in their annual subscriptions.

The members monthly magazine will be on line and members who require a hard copy may acquire same on request and for a nominal fee subject to minimum uptake numbers.

Members who wish to pay their membership fees in recurring payments should activate the payments on their banking portal. Members will receive the early bird discount only if their fees are fully paid by 31 March 2020.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