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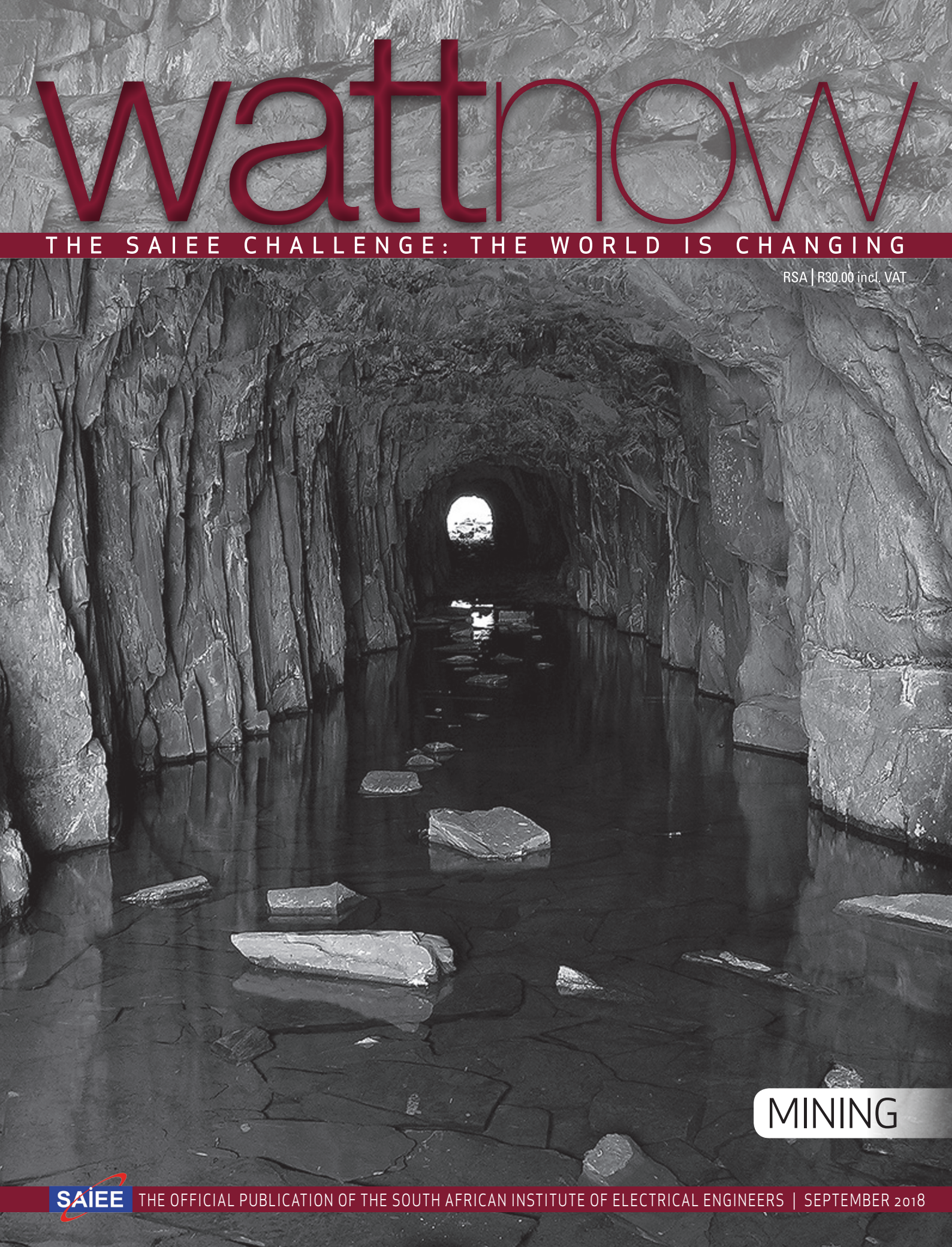
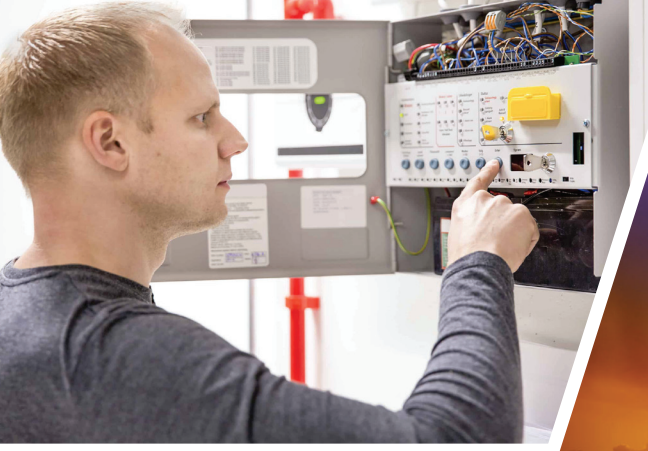


MINING

SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | SEPTEMBER 2018



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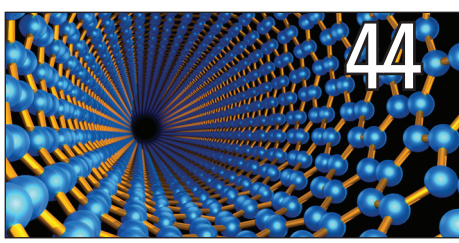

GENERAL

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It is September, and in this issue, we focus on Mining.

Though gold was discovered near Krugersdorp in July 1852, mining activities started successively in various places on the Witwatersrand, with the first gold from the Main Reef on the Witwatersrand being mined in 1885. This lead to the establishing of Johannesburg.

This issue sports a few interesting articles on mining. Our first feature article "Fast Rock Segmentation" (pg 22) presents a novel approach, using artificial intelligence.

Our second feature article, "Data-Driven Reliability in Mining" (pg 28) discusses safety checklists and why it is pertinent to use the correct checklist. When last did you check the content of your checklists - and how up-to-date is the list?

Page 34 features an excerpt from the National Coal Strategy for South Africa, published by the Chamber of Mines, which makes for fascinating reading. Readers are welcome to email me if you want to read the complete pdf document.

Dudley Basson brings you another article, on how new technologies innovate the scientific developments of Carbon Nanotubes.

The Annual SAIEE Banquet is only a few weeks away! If you would like to rub shoulders with decision makers in our industry, please contact Gerda (geyerg@saiee.org.za) now to book your table for 10 (R6000), or individual tickets are on sale at R650 p/p.

Join us for a night which promises excellent fun!

Herewith the September issue, enjoy the read.

Minx

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

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DR HENDRI GELDENHUYS
2018 SAIEE PRESIDENT

Mining: Where are we going?

Imagine South Africa without diamonds, gold, platinum, chrome, coal, iron ore, manganese, copper and more! We would have had a different development history and demographics today. Johannesburg would not exist and the "Free State" would be the entire territory between the Vaal River and the Orange River, including the part around Kimberley (just to jog your memory on some South African history).

I think the earliesr "Industrial Revolution" began with humanity's discovery and use of mining leading to the bronze and iron ages. It was these early adoptions of technology that stared us on the road to where we are today. In the first Industrial Revolution, steel and other mined metals became the foundation on which civilisation was built. Many of these materials are taken for granted today, and attract little attention in our engineering minds, but take for example steel out of our world and try to build any structure...

Mining is an essential industry in South Africa; it employs directly and indirectly over a million people. It is one of the vital forex earners for South Africa, and it generates more than 90% of the consumed electricity in our country. The electrical engineering industry, and our members, forms an essential part of this industry's infrastructure. Many of our members work in the mining sector.

StatsSA report that in 1980, Manufacturing (21%) and Mining (21%) were the leading contributors to the South African GDP. In 2016 Finance (20%) and Government (17%) are the leading "contributors" to the GDP! Mining is now ranking number 6 at 8% contribution (and Manufacturing has fallen back to position 4 at 13%.) These are disturbing statistics and need further investigation.

Safety in mining should remain one of our key objectives. The Chamber of Mines' reports indicates that there has been substantial improvement in the safety record of mines over the last twenty years. This is a commendable achievement!

Safety is an ongoing technical and organisational culture matter. It requires management and staff's full continuous commitment, to maintain current safety regulations and continuing reinventing these regulations for prosperity.

Electrical engineering is both a potential source of accidents as well as a key technology provider of automated safety protection systems. In both of these cases, our members and industry play a leading role.

H Geldenhuys | SAIEE President 2018
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WATTSUP

Entrepreneurs! Now is the time to change lives and grow revenues

All signs point to Africa as the most extraordinary place to be and do business in the future. So, how are we going to do business?

This is the question posed by Musa Kalenga, the enthusiastic entrepreneur and strategist who was named one of the Top 200 young South Africans by Mail & Guardian, at a recent Entrepreneurship To The Point Session hosted by Property Point, the Growthpoint Properties initiative.

The answer to doing business that he offers entrepreneurs, even in this digital age, is humanity.

"Humanity is the new black; it is how we are going to be the next powerhouse of this globe," says Kalenga. *"Being human is the one thing that will enable us to survive in the age of augmentation."*

Kalenga is obsessed with using technology to empower the digitally invisible. *"We can send people to the moon but we can't feed people on earth? This is a problem,"* he cautions, *"because unless we're making fundamental business model changes, we won't have a market for the future."*

He took the Entrepreneurship To The Point audience on a journey, highlighting the sweet spot where technology and creativity merge.

Looking at how African entrepreneurs should respond to the age of augmentation, he uses the shocking November 2015 Paris attacks as an example. Facebook activated its Safety Check function, Uber alerted its drivers to take people to safety, and Airbnb operators took in anyone in need.

"While these are tech businesses at their core, they displayed decidedly human responses. They also didn't have to redo their business model to respond in a more human way," points out Kalenga. *"The technology journey that communities and consumers have to go through must match ours as brand creators, value seekers and entrepreneurs."*

Doing this is simpler than you may think. Technology's intersection with humanity is all about finding simple, meaningful solutions.

Musa Kalenga
Entrepreneur & Strategist

He points to the trend of impact investment – an approach taken by some of the world's richest family businesses. Impact investment means finding opportunities that are solving human-centred problems and creating value for the humans that we seek to serve, and then figuring out how to make revenue as a business. Essentially, it puts doing good before making money. This is where humanity, technology and entrepreneurship are on course to meet and power the extraordinary future of business in Africa.

"Human beings are at the top of the food chain because we can understand a small and simple thing, then develop it for different purposes all the time. Also, because we can rally around common cause and purpose. Enhancing quality of life in the way people experience technology is key to continuing to solve problems, not only in Africa but across the globe," concludes Kalenga.

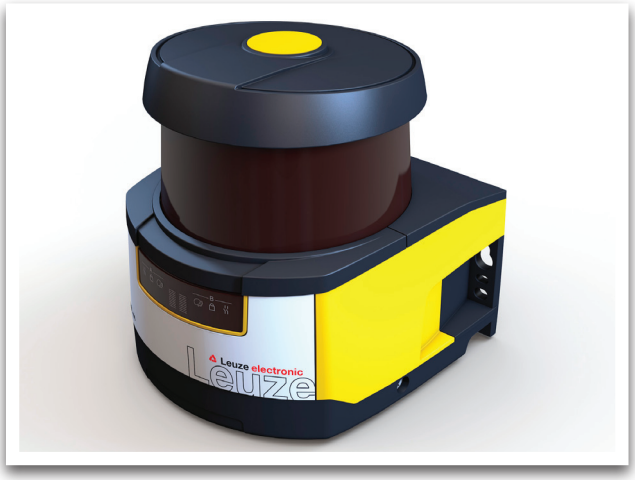
Versatile Condition Monitoring System

Instrotech is offering the latest Monitran condition monitoring system, that monitors and logs vibration on as many as 32 channels. Parameters that can be measured include velocity and envelope g, as well as temperature.

Known as the MTN/5032, the microcontroller-based system has an easy-to-navigate 18,5cm colour touch screen that enables users to set alarm thresholds and delays either individually or across all channels. Data sampling periods, ranges and accuracy levels can also be easily set.

The channels are configured to customer specifications and offer 12 bit sampling, with an input range of 25 mm/s for velocity and 10 g for envelope g. Temperature channels, which can be used to monitor

Reliable Navigation with Leuze Safety Laser Scanner



The Leuze RSL 400 safety laser scanner.

The Leuze RSL 400 safety laser scanner with measurement value output is setting new standards in the reliable navigation of automated guided vehicles (AGVs).

Available from leading sensor solutions provider Countapulse Controls, the new Leuze RSL 400 safety laser scanner is the result of many years of experience in the development of safety technology.

This compact safety scanner combines safety technology and qualitatively superior measurement value output in a single device. This enables reliable safeguarding and navigation of AGVs. Measurement value output is optimised to navigation software that functions according to the principle of natural navigation with SLAM (Simultaneous Localisation and Mapping).

Johannesburg-based Countapulse Controls offers industry access to skilled technical personnel that can advise on sensing solutions across a broad range of applications.

bearings or gearbox oil for example, can monitor up to 120°C.

"The versatility of our MTN/5032 makes it ideal for monitoring a wide range of rotating machinery, including industrial, power, water, mining and marine applications," said Andy Anthony, Monitran's managing director.

For more information and a full specification on Monitran's MTN/5032 microcontroller condition monitoring system, contact Instrotech on sales@instrotech.co.za.

Liquid Telecom delivers first Microsoft ExpressRoute within Africa

David Behr

Leading pan-African telecoms group Liquid Telecom has delivered the first Microsoft ExpressRoute service peering in Africa – offering customers better performance, tighter security and lower latency.

Microsoft ExpressRoute, part of Liquid Telecom's CloudConnect offering, allows businesses to establish private connections to Azure. Previously, customers could only access ExpressRoute via peering locations in Europe.

Liquid Telecom recently deployed an ExpressRoute link for the Western Cape Government, which is overseeing a major upgrade to communications infrastructure in the region - marking it as the first customer with a direct private connection to the Azure Cloud that is exchanged locally in Africa.

The Western Cape Government said: *"Liquid Telecom's CloudConnect service has significantly increased the performance of our cloud services and will support the rollout of leading-edge cloud solutions to more of the region."*

Liquid Telecom is the only Microsoft partner to be providing an ExpressRoute service across 8 African countries on its own fibre, including South Africa, Zimbabwe and Kenya.

"Our advanced ExpressRoute offering is another important step forward for Africa's Cloud. Liquid Telecom's CloudConnect service is strongly positioned to be the highway that links businesses to a whole host of leading local and global cloud services," said David Behr, Group Chief Product Officer, Liquid Telecom.

Liquid Telecom will also be able to offer ExpressRoute directly to the Azure Cloud in Africa when it goes live in data centres in South Africa later this year. For businesses in Africa, this will mean:

- Liquid Telecom can guarantee the performance of the link end-to-end in a Service Level Agreement by routing all traffic within Africa.
- This will translate into significantly reduced latency – due to the closer proximity of the data centres compared to the European-based facilities.
- All data residing in the South African Azure data centres will be POPI compliant.

WATTSUP

How to get more troubleshooting and preventive maintenance done in less time

The Fluke 789 ProcessMeter is the ultimate troubleshooting tool for electricians and instrumentation professionals, combining the functionality of a loop calibrator with the power of a digital multimeter. By equipping the 789 with a temperature measurement module and the wireless data logging capabilities of Fluke Connect™ with ShareLive™ video call (sold separately), process technicians can now do a lot more while carrying a lot less. And with its built-in, selectable 250 ohm HART® resistor, it eliminates the need to carry a separate resistor.

Since the launch of the Fluke Connect™ app, Fluke has heard from several customers about how Fluke Connect-enabled tools help get more done in less time. John Bohling, a service technician and member of Pipefitters Local 597 in Chicago, USA, recently shared some troubleshooting and preventive maintenance tips he collected.

Temperature Module Monitor temperature and electrical at the same time.

John used the FC Wireless K-Type Temperature module for day-to-day troubleshooting applications. It measures temperature in one location and then wirelessly relays the results to a smart phone (with the Fluke Connect app installed). This comes in very handy for checking multiple components of heating and cooling systems simultaneously.

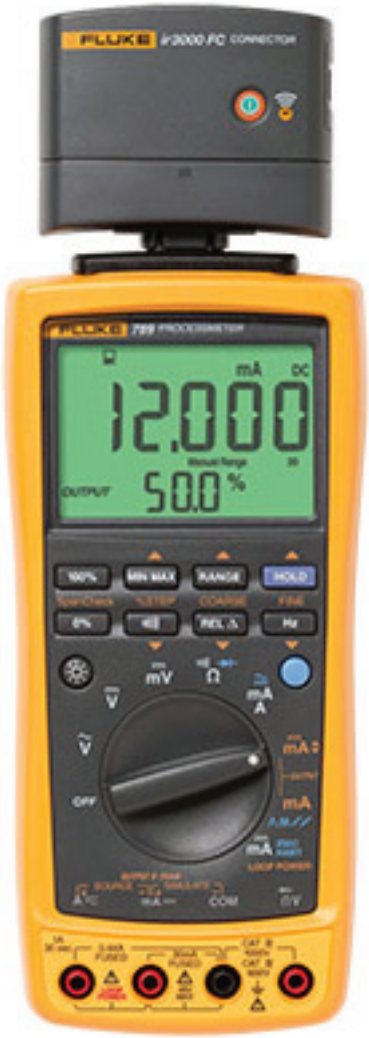
For example, at one site, a temperature module was set up to monitor refrigerant line temperatures while he worked on the refrigeration components located elsewhere. He also used the K-type temperature module on split system-style chillers. In one instance the chiller, which had a microprocessor-based control, was located in the basement; the air-cooled condenser was located on the roof.

John was able to oversee the fan-cycling controls by measuring the motor amp draw using the a3000 FC current clamp. At the same time, he monitored the liquid line temperature using the temperature module, and observed a specific percentage on the microprocessor in the basement. He viewed the results from all three tools simultaneously, in real time, on his smart phone.

FINDING A NEEDLE IN A HAYSTACK

With the Fluke Connect dc voltage module, John measured a 0-10 V dc signal to a variable frequency drive (VFD) located in a supply air cabinet. The third party panel was inaccessible so the VFD was the only place to test. *"If I had tried to monitor the third-party signal at the VFD with a standard meter, it would have tripped an alarm due to 'no proof of air flow' by the air flow switch,"* he said. *"Using the Fluke Connect dc voltage module I found that the building automation system was not sending the proper ramp signal when duct static pressure dropped."*

This same FC module helped him find a chronic problem in a dc power supply that



Fluke 789 with IR3000 - a temperature measurement module and the wireless data logging capabilities of Fluke Connect™

was intermittently dropping the 5 V dc it supplied. This caused the chiller to fail and trigger an alarm. He left the dc voltage module on the power supply overnight.

"The results showed that the power supply dropped voltage and then restored itself. I replaced the power supply with confidence the next day," John said. "These meters will be of incredible value as safety concerns rise and more tests need to be conducted outside of the electric panels and in more remote locations."

For more info, Contact Comtest for Fluke 789 Process meter on sales@comtest.co.za.

Building long lasting relationships with the community

From left: Dr. Joyce Mwangama Dr. Melissa Densmore, Ms. Tara Caetano, Dr. Jiska De Groot, Mrs. Joyce Mtimkulu and Mrs. Khanyakazi Dioka.

A team of IEEE volunteers at the University of Cape Town (UCT) implemented the first EPICS in IEEE Project outside the US in 2009 at Thandokulu High school, Mowbray, Cape Town. According to Dr. David Oyedokun who has been involved with EPIC-in IEEE project in Cape Town since 2010, the artifact from that project is still in use for demonstration during Open Day at the department of electrical engineering, UCT. Nine years later, 30 female leaners from the same school received an all-expenses paid invitation to participate in a Women in Energy Luncheon at IEEE PowerAfrica Conference in Cape Town on 26 June 2018. During the luncheon, a panel discussion was held between the learners and an all-female panel which consisted of engineers, scientists and an economist. About 60 additional conference attendees joined the session. The discussion themed Women in Energy covered the role of mentorship in career development, support mechanisms in industry, sensitizing colleagues to making the engineering workplace female friendly, career development and progression and leading a successful professional career as a mother.

Dr. David Oyedokun with learners from Thandokulu High School

Myriad opportunities remain available for women in the energy and engineering and the learners in attendance were encouraged to hear that they had taken the first step which is showing interest. The discussion was moderated by an outstanding professional engineer from Eskom, Mrs. Khanyakazi Dioka,PrEng. The panelists congratulated the learners for attending the discussion and implored them to be steadfast in their quest for knowledge and information about the engineering. The learners were delighted to know that within the IEEE, structures such as Women in Engineering (WiE) and Women in Power (WiP) seek to support the career advancement of women in the field and create networking opportunities.

As testament to how well the learners received enjoyed the session, in her input to the discussion said that she would like to see the panelist visit their school and other schools in her community so that more leaners can benefit from the wealth of knowledge and information that was shared.

The learners will be invited to participate in developing a renewable energy (RE) center at the school, a project spearheaded by Dr. David Oyedokun. The project will showcase both vertical and horizontal axis wind turbine technologies as well as solar PV. The objective of the project is to create a platform through which pre-university learners in the area can interact with RE technologies, electrical design, programming, energy economics, develop and sustain interest in electrical engineering.

The panel discussion was facilitated by Ms Estee Amana, Dr. David Oyedokun, Mr. Thato Semoko, supported by IEEE South Africa Section, IEEE PES, IEEE Young Professionals (Cape Town) and the SAIEE.

WATTSUP

The SAIEE Head Office celebrates!

SAIEE's Sue Moseley, Manager of Continual Professional Development (CPD) & Training Academy, who has been with us for 11 years announced her engagement to Professor Jerry Walker. Jerry has spent 23 years in the engineering industry. He is a director of his own company, Walmet Technologies (Pty) Ltd, and is a Visiting Professor at the Vaal University of Technology, as well as one of SAIEE's popular CPD lecturers.

The SAIEE Head Office are super-elated that one of our own has found love again! Congratulations to the both of you; we wish you both an eternity of love and happiness together.

Uganda audits Pepsi plant as part of CEA training

A group of Ugandan trainees benefited from adding practical training to their theoretical energy auditor training resulting in an above average passrate in their examination for the group.

The Certified Energy Auditor (CEA) program of the Association of Energy Engineers (AEE) was delivered over 2 weeks with the AEE CEA examination in Kampala Uganda, to a group of 10 energy professionals. The theoretical training modules of the AEE's CEA was complimented with a practical session within the nearby Crown Beverages Pepsi plant.

The Energy Training Foundation (EnTF) was contracted by GIZ PREEEP to deliver the CEA program with a practical component and to conduct the internationally recognized AEE CEA examination. All candidates that achieved a passmark of 70% or higher may apply for international Certification as a CEA with the AEE through the AEE's Certification Administrator in Sub-Saharan Africa, the EnTF.

A total of 10 candidates were trained in energy auditing theory and prepared for the international examination, with a practical session to learn the use of energy audit equipment and report writing requirements. Performing the tasks learnt in the theory embedded knowledge more effectively and was appreciated by the learners as well as enjoyed. Albert Williams, and Industrial Engineer with CEA, CEM, CMVP and REP certifications, as well as an AEE accredited trainer for CEA and CEM said *"The practical sessions were invaluable and candidates appreciated and enjoyed the opportunity to put to practice what they learnt in class"*. Candidates were examined after the course, and achieved an exceptional 80% pass rate where 8 of the 10 candidates have progressed to the certification application process for peer-review and verification to become fully Certified as CEAs. Candidates were required to provide their individually finalised energy audit reports to the facilitator for marking, and collaboration into one report for submission and use by the practical site.

Take-Up Broadens For Dry-Type Transformers

Two 1250 kVA 11 kV/400 V dry-type transformers with complete with on-load tap changers.

As the market recognises the numerous benefits of dry-type transformers, specialist supplier Trafo Power Solutions has, in recent months, provided custom-designed units for a range of applications within South Africa and in other parts of the continent.

According to Trafo Power Solutions Managing Director David Claassen, an increasingly popular application for their transformers has been in large industrial companies which leverage solar power to augment their energy needs during daylight hours.

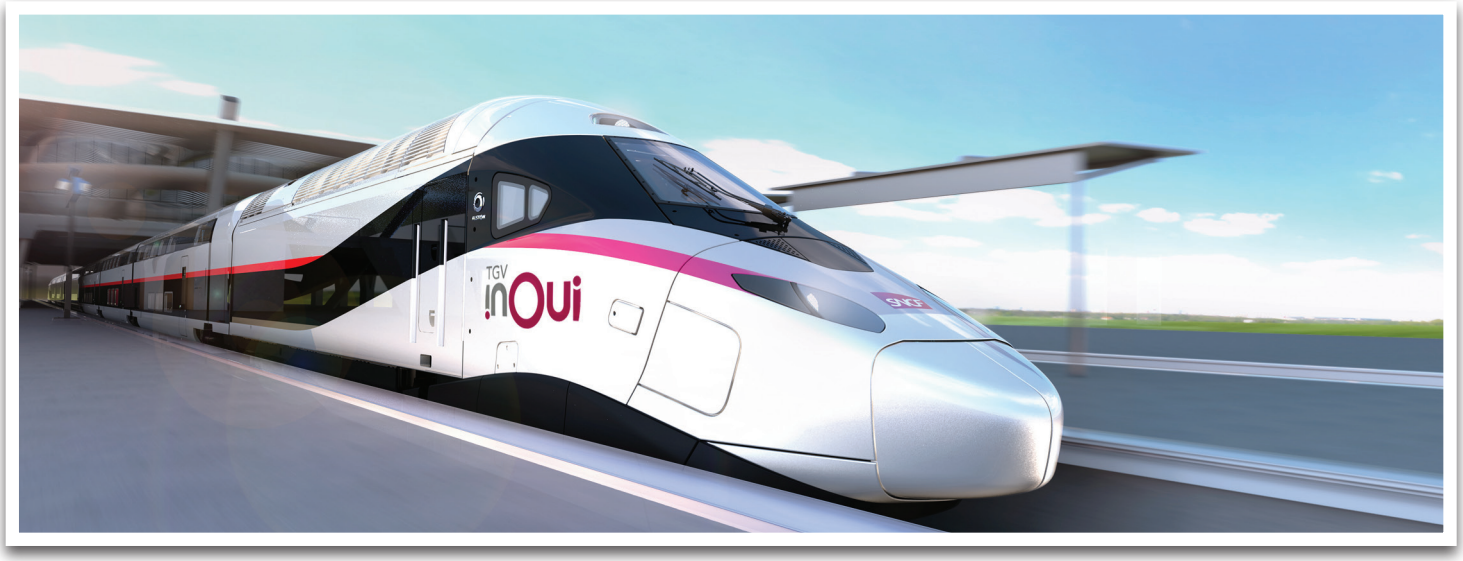
"Where companies have the roof or ground space to accommodate photovoltaic cells, many are taking advantage of solar power to reduce consumption from Eskom and cut their monthly electricity bill," says Claassen. *"With our experience in supplying the necessary specialised transformers for this purpose, we design and install units that are capable of supplying a 100% non-linear / inverter load while also providing electrostatic shielding between the medium voltage and low voltage sides of the transformer."*

Trafo Power Solutions recently installed and commissioned 1250 kVA and 1000 kVA units to serve large industrial bottling plants in Gauteng and Bloemfontein respectively. In another customised solution developed in response to a specific challenge faced by a customer, the company recently helped address the frequent voltage fluctuations in supply being experienced at the South African manufacturing facility of an international pharmaceutical company.

The supply and installation of two 1250 kVA transformers for this unique application was also completed in record time, including the commissioning and testing of the system within just three days of the units arriving from Hammond Power Solutions' manufacturing facility in Italy. There has also been steady demand for dry-type transformers in commercial buildings and hospitals, where users are looking to ensure high levels of safety in relatively confined spaces, while enjoying low maintenance requirements.

WATTSUP

Alstom to build 100 next-generation very high speed trains



Avelia Horizon high speed train.

The Board of Directors of SNCF Mobilités has approved a firm order for 100 next-generation Avelia Horizon high-speed trains (TGV) at its meeting in July 2018.

This new generation of very high-speed trains addresses to ambitious goals in terms of competitiveness of the rail sector and profitability for SNCF, with a total acquisition cost 20% lower than that of the previous generation. The teams of experts working on this project for two years have risen to the challenge of specifying a new train at a reduced cost of €25 million per trainset, with an additional budget of €190 million for options and services .

Avelia Horizon will consist of two innovative power cars of reduced length, combining high performance and compactness, and articulated double-deck passenger cars. Their design allows for a 20% increase in passenger-dedicated areas, allowing the train to accommodate up to 740 passengers in the highest-capacity configuration chosen by SNCF.

Maintenance costs will be more than 30% lower than those currently recorded by SNCF. The train's maintainability is considered from the design stage, with a remote diagnostic system for predictive maintenance, which improves the trains' reliability and availability. Many of the components have an optimised design to simplify, reduce, and allow longer intervals between maintenance interventions.

Thanks to its aerodynamic design and a more efficient traction drive, the next-generation TGV will consume 20% less energy than existing TGVs.

"This order is the successful fruit of the collaborative work of SNCF and Alstom. Alstom's Avelia Horizon solution meets the technological, economic and competitiveness challenges of SNCF," said Henri Poupart-Lafarge, Chief Executive Officer of Alstom.

2019 MEMBERSHIP FEES

EFFECTIVE FROM 1 DECEMBER 2018

Council meeting held on 7 September 2018 approved subscription & entrance fees as from 1 December 2019 will be as per schedule indicated below.

PLEASE NOTE: In terms of Bylaw 3.2 annual subscriptions are due on 1st December 2018.
Council agreed to a discount for fees paid before 31 March 2019. Members are therefore encouraged to pay promptly to minimize increase.

Grade of Membership	**Annual Subscriptions** *Paid before 31 March 2019*		**Annual Subscriptions** *Paid after 31 March 2019*		**New Members** **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	120	105	144	126	144	126
After 6 years study	1 246	865	1 495	1 038	1 495	1 038
Associate	1 246	865	1 495	1 038	1 495	1 038
Member	1 377	956	1 652	1 147	1 652	1 147
after 6 years	1 069	1 117	1 931	1 340	1 931	1 340
after 10 years	1 684	1 168	2 021	1 402	2 021	1 402
Senior Member	1 684	1 168	2 021	1 402	2 021	1 402
after 6 yrs/age 40	1 825	1 266	2 190	1 519	2 190	1 519
Fellow	1 825	1 266	2 190	1 519	2 190	1 519
Retired Member *(By-law B3.7.1)*	774	536	929	643	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 R2580.00 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 R144.00.
2. The 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 2019 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.

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What is the future for electricity utilities?

Rising primary energy, capital and operating costs, and associated increasing grid electricity prices, are ocuring at the same time as the costs of distributed utility-scale and "behind-the-meter" renewable energy and energy storage solutions continue to fall.

BY | ROGER LILLEY | EDITOR | EE PUBLISHERS

Andrew Ericksson

Prof Anton Eberhard

Piet van Staden

Power utilities all over the world are facing profound changes. These changes, Dr Andrew Eriksson, an energy consultant from Zurich, told an enthusiastic audience recently, will result in the utilities of the future taking on very different roles with new financial models in order to survive the sweeping changes which technological developments will bring to the electricity industry.

The audience, which had packed the Franklin Auditorium at Eskom's Megawatt Park for the recent "*Electricity utility of the future*" debate, which was jointly hosted by SAIEE and EE Publishers, heard from a panel of speakers that electricity will be traded between users in future, using utility-provided infrastructure. These users will produce electricity for their own use and sell the excess to neighbours or the utility.

Rising primary energy, capital and operating costs, and associated increasing grid electricity prices, are occurring at the same time as the costs of distributed utility-scale and "behind-the-meter" renewable energy and energy storage solutions continue to fall. Simultaneously, the demand for environmental sustainability, with "cleaner" electricity, lower pollution, reduced water use and lower CO_2 emissions to mitigate climate change, is accelerating.

Utilities are facing declining sales volumes while their costs continue to rise. Increasing tariffs are not the solution, as this action tends to drive greater interest in alternative sources of electricity and more efficient equipment. The decision to increase tariffs ultimately leads to the so-called "utility death spiral", in which the power utility's revenues fall below its costs making the entity uneconomic.

Under the chairmanship of Maanda Ramutumbu, an SAIEE councillor and senior manager at Accenture, three experts presented their views and answered questions from the audience.

The panellists were:

DR ANDREW ERIKSSON

Dr Andrew Eriksson said the "old normal" is gone. Renewable energy sources are here to stay – and grow. Complex technologies vastly complicate the issue, making earlier success factors no longer valid, he said. The future of the energy sector will be driven by the users of electricity. Therefore, we need to allow a bottom-up "revolution" to determine the future of the electricity market. According to Eriksson, electrical energy has to be a low-priced commodity if the economy is to grow. New technologies can be primary enablers as long as the regulatory environment is not allowed to become an inhibitor.

Eriksson expects a future electricity industry to operate in an integrated, multi-dimensioned market with aggregators as key players, allowing for a wide scope of ancillary service providers. These forms of utility will not need nor want a heavy asset base. Rather, platform providers will shape and drive the market.

Therefore, a new power sector techno-economic paradigm is needed. Energy markets will need to be liberated, where electricity is sold as a commodity – dynamically priced according to the principles of supply and demand. End users will demand and ultimately enjoy flexibility and the ability to choose from a number of suppliers. In the same way, end users will be free to choose to install their own independent RES (as prosumers) should they so wish, he said.

Once distributed energy generation becomes wide-spread, the grid infrastructure will need to be upgraded to support bidirectional current flows between users and the utility. Economics mainly, plus technology, will drive grid balancing and provide business opportunities. Utilities will focus on the distribution, rather than the generation, of electricity, meaning that the most agile utilities will compete and win supply opportunities without having their own production facilities. This will result in a socio-politically driven environment, where economic power is increasingly with the end-consumer/prosumer. Traditional generation, being at the far end of the chain, will no longer be in control.

For this vision to succeed, Eskom must be willing to abandon its legacy beliefs, acknowledge that it needs to adapt or it will die. This means accepting the enablers of profound change in the way things are done; to accept the power of aggregation – which is multidimensional; to understand the power of digitalisation; and accept the independence of prosumers and the importance of their values and needs.

PROF ANTON EBERHARD

Prof Anton Eberhard said that Eskom needs to restructure before it is too late. Eskom's troubles are in no small measure, related to its current structure and business model. The power utility cannot trade its way out its current debt crisis because electricity sale volumes are lower than a decade ago and tariff increases merely depress demand and encourage defection from grid (utility death spiral).

Eberhard says the South African power market is on the cusp of a revolution with new gas, renewable energy and storage technologies becoming more cost effective. As such, they are better suited to the needs of future generations of electricity users who will trade with one another and the utility across a wired infrastructure. As power flows both ways, advanced metering and payment systems need to reflect time differentiation in energy costs as well as peak-coincidental capacity charges for networks and flexible resources. The heart of the power system (the grid and the transmission system) needs to be protected and placed in a separate entity. Eskom's conflict of interest as both a generator and single-buyer of power from IPPs needs to be removed. The industry needs to restructure South Africa's power market and Eskom needs a new business model. The unbundling of Eskom's generation and transmission networks, already part of the Energy Policy White Paper, must be implemented, said Eberhard.

PIET VAN STADEN

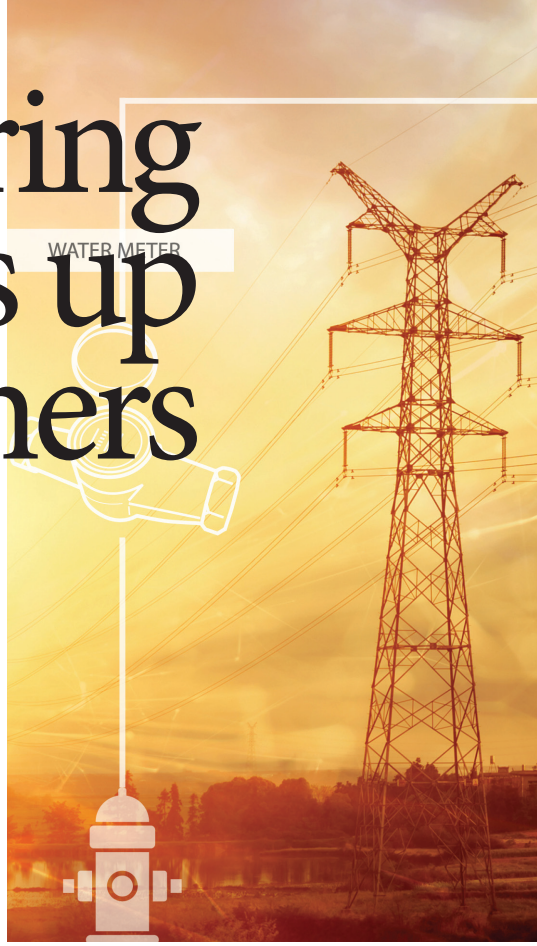
Piet van Staden said new technology breakthroughs in renewables (grid-based, distributed and embedded), gas and storage as back-up, smart grid solutions, sector coupling with EVs present the industry with great advantages. The idea of large base-load generation has become less viable. However, energy transition presents severe risks (and some opportunities) to industrial power users, and by implication to the electricity industry and the country as a whole, he said.

A well-managed, seamless transition is preferable to a disruptive shock leading to de-industrialisation and defaults. According to Van Staden, this transition will need strong and visionary leadership to unite all social partners behind a common vision of a decarbonised, low-cost and job-rich future. Political will and tenacity to make unpopular decisions will be required if we are to put the country on the right pathway towards sustainable economic growth.

SUMMARY

South Africa's electricity system needs an overhaul. The single, state-owned, vertically integrated behemoth is no longer sustainable. The optimal end state of the South African electricity supply industry is clear, given the sustainable competitive advantages the country enjoys from ample wind and solar resources, plus available space to harvest these resources. The country must find a way to transition to a low carbon economy and do it within a time frame that can potentially enhance the competitiveness of the economy. wn

Smart Metering System powers up customers



Property portfolio managers and tenants in both commercial and residential precincts across the country are facing punishing escalations in water and electricity tariffs on an annual basis. Consequently, making every cent count has never been more important, nor has the need to ensure that billing is accurate and that the collection of monies is efficient.

Invirotel, a specialist division of the Proudly Bidvest group's Voltex, has put the professional management of utility provision and client control at the heart of its Invirotel Smart Metering Management System. This two-pronged focus delivers in multiple ways: efficiency targets are met, carbon footprints are more effectively reduced, muscular usage data guides the client in assessing future capex layout and, critically, business stability is not undermined by inaccurate bulk billing or by the difficulty of collecting monies from tenants and co-users.

Invirotel was established in 2011 to cater for the growing need in smart energy management solutions and to pursue innovations in the green technology sector. As a distributor of smart meters, its main target markets are municipalities, commercial property owners and managers of tenanted real estate.

It is expertly skilled in software development and management solutions that create a transparent niche reporting and monitoring output so that customers have control over their electricity and water consumption.

WHAT MAKES THE SYSTEM SMART?

Advanced Metering Infrastructure (AMI) underpins this highly functional yet surprisingly simple and affordable energy metering solution. AMI is an integrated mix of smart meters, communication networks and data management systems that enables two-way communication between utilities and customers.

The Invirotel electricity meters - which are either single or three phase – can operate in either pre- or post-paid modes and use existing power lines to communicate with the data concentrator unit (DCU) which is capable of reading the meters remotely. The water meters connect with Invirotel's cloud-based software system directly using wide area radio frequency communication. The concentrator allows two-way access to all meters and can be connected with up to 400 metering endpoints.

A COMPREHENSIVE TURNKEY OFFERING

The Smart Metering Management System, which incorporates a Utility Account Administration System, is fully supported by dedicated technical teams who provide a range of end-to-end services. Water and electricity usage audits are carried out prior to the drawing up of installation plans and scheduling. Software integration and customisation forms a crucial part of the process. A winning feature of this system is that it can work with smart meters which are already being deployed: Invirotel's meter management software is compatible with the majority of smart metering brands allowing customers to make full use of existing assets. Certificates of Compliance (SANS 10142) are issued once the meters and all related infrastructure is in place. Ongoing assistance is provided to customers who want help with analysing power quality and improving their energy efficiency. The Utility Account Administration System verifies and validates bills produced by any South African municipality and utility company

as well as bills received from private metering companies. The verification and validation is carried out automatically using the data-rich tariff engine and real-time data received from the meters.

A SYSTEM DESIGNED FOR YOUR CUSTOMER'S CONVENIENCE

The entire system has been designed to appeal to customers on numerous levels, with 100% accurate billing data topping the list. Digital, tamper-proof meters preclude errors and fraud, and require zero maintenance. The two-way communication between the meters and the user interface allows for real-time sms and email notifications of faults and incidences of attempted fraud.

As a result, outage detection and restoration of services is that much faster. Additionally, the Invirotel online dashboard gives both property managers and tenants the option to zoom in on their consumption data so as to understand usage patterns. If tenants use private vending, they can monitor consumption, in addition to purchasing electricity vouchers, using the handy Voltex Mobile Prepaid App. Controlled and gradual cut-offs for non-payments are also made easier using this smart metering solution.

VITAL TOOL FOR PROPERTY MANAGERS

The management of and billing for energy and water consumption is a headache for many property managers. Invirotel really does make the whole process supremely easy and accurate. Imagine being able to manage an entire property portfolio centrally. The flexibility of Invirotel means that building assets can be metered in their entirety or in individual sections using either bulk or sub-metering. Keeping track of common area consumption

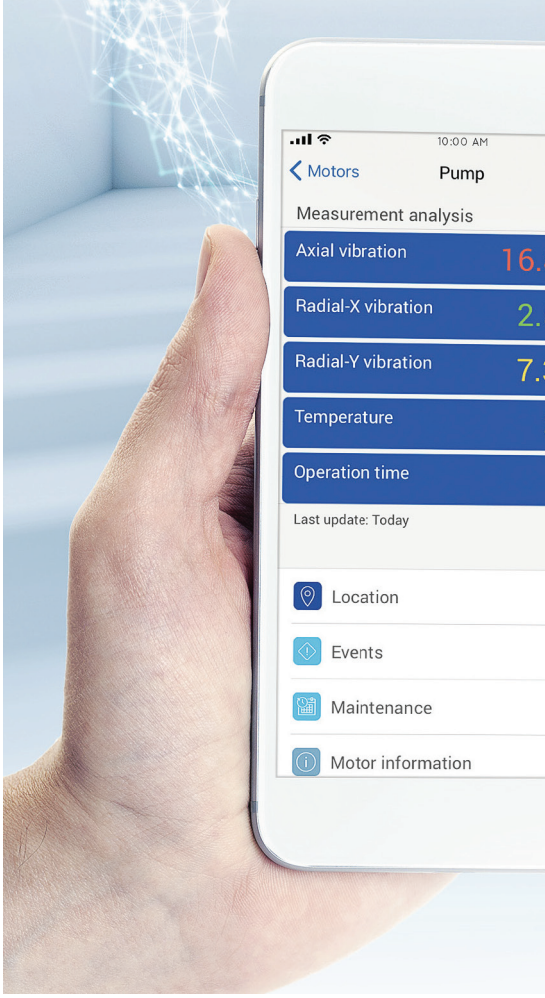
has never been easier and leaks can be quickly detected. The big data harvested from the meters opens the way for managers to create revenue and energy/water balancing reporting as well as draw benchmark reports both intra and inter portfolio, for building categories, per number of users or per GLA. Reporting periods from as current as half-hourly can be selected while load-switching schedules can be defined for improved efficiency. The automated meter-linked billing process, which does away with billing disagreements between manager and tenant, is a further invaluable tool.

NO CONTEST

If your aim is to partner with your customers to manage their assets expertly and eco-consciously, then installing the Invirotel Smart Metering Management System should be a serious consideration. In a tough economy, profit growth gets tougher. Drastically improving electricity and water management will be a key focus for any property manager.

By introducing a highly professional and reliable smart metering system to their portfolios, they can concentrate infrastructure funding where it is needed most, put an end to wasteful expenditure and see their bottom-line reflect healthy growth. wn

Motor Scan Set To Change Industry



Leveraging digital technology is said to be key to participating in the next wave of economic growth. At the very least using it will allow mines, process plants and other industrial operations to reduce operating costs.

Fanie Steyn, Manager Rotating Machines at Zest WEG Group, says one of the areas that stands to be most impacted is predictive maintenance. *"This is where access to accurate data can be used to increase production efficiency and reduce downtime, and for the first time industry will be able to do this remotely with electric motor installations,"* he says.

WEG Motor Scan is a brand new solution available from Zest WEG Group that facilitates remote monitoring of electric motor installations. This innovative technology allows engineers and maintenance personnel to make informed decisions about the health of installed motors and react accordingly, depending on the data captured.

Steyn says that the WEG Motor Scan solution uses Industry 4.0's digital technology including the Internet of Things (IoT) and big data analytics. The technology allows for the monitoring of running hours, measurement of vibration and surface temperature as well as providing data on speed and start/stop time. The load and efficiency will be included in the second phase. Data is extracted via Bluetooth using a smart device with the innovative app that is available on android and iOS phones and tablets. Users can also access the data on laptops and desktops via a dedicated web portal.

Powerful analytics help to process the data and predict pending failures or hidden problems based on frequency spectrum analysis. Warning levels are pre-set based on acceptable baselines of temperature/vibration and sophisticated software is able to plot performance curves with the captured data. The data is sent to the cloud for storage facilitating fast access and more accurate decision making.

"Using the WEG Motor Scan solution minimises the requirement to manually collect and monitor data, and it eliminates the guesswork from preventative maintenance routines," he explains. *"This removes the inefficiency of reactive maintenance and assists in minimising motor failure."*

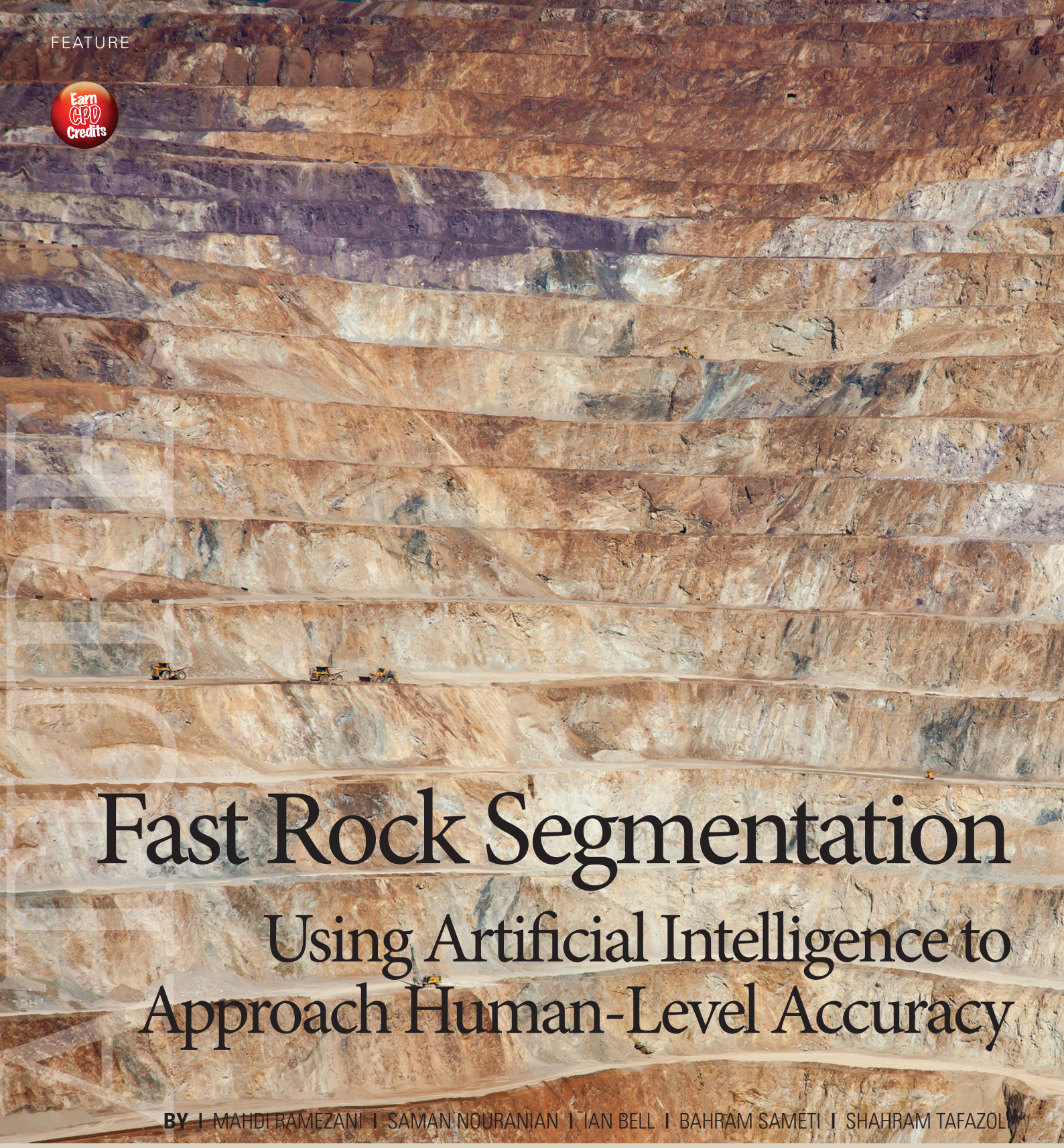
WEG Motor Scan monitors motor data, stores it in the cloud for access via App and an IoT platform.

WEG Motor Scan solution is currently available for frame sizes from 63 to 450, providing this innovative monitoring solution for motors ranging from 0,18 kW up to 1250 kW. It can be fitted on newly manufactured motors or retrofitted to existing installations. The sensor itself is battery powered and has an estimated life span of three years. It is designed to work in ambient temperatures ranging from minus 40°C up to 80°C, has a protection rating of IP66 and can operate in Zone 1 areas with a T4 temperature rating.

Offering optimum flexibility, the sensor can be used on direct online starting as well as variable speed drive (VSD) applications.

"This is a major value add for our customers and the market and will in reality set a new benchmark in predictive maintenance," Steyn concludes.

Earn CPD Credits



Fast Rock Segmentation

Using Artificial Intelligence to Approach Human-Level Accuracy

BY | MAHDI RAMEZANI | SAMAN NOURANIAN | IAN BELL | BAHRAM SAMETI | SHAHRAM TAFAZOLI

A particular type of deep artificial neural network is used as a pixel classifier to build the models. The proposed classifier provides a label for each pixel, (edge, rock, or fine) by analysing a plurality of pixels within the image. Advances in the field of machine learning allow the developed network to contain a large number of parameters. The increased number of parameters is a substantial factor in the classifier's ability to better predict the correct class for each pixel.

The proposed deep learning based segmentation approach is combined with

Image-based rock fragmentation sensing in mining and quarry applications includes a vital rock boundary delineation step, which is commonly referred to as rock segmentation. This article presents a novel approach to solve this problem, using artificial intelligence. In the proposed technique, prior knowledge of previously analysed images is encoded into mathematical/ statistical models. A set of individual labelled images are used as training inputs. These images are used to train neural networks through an optimisation process. The systems can then be used in real time for rock delineation.

3D-imaging followed by post-processing to provide a unified fragmentation sensing solution. Results of the automatic segmentation are compared with human labelled segmentations using the percentage passing curves for 64 rock images of size 1,280 x 960 pixels.

Mines and quarries can see significant productivity and performance benefits by controlling material sizes. During the past decade, image-based fragmentation analysis has been applied to estimate rock size distributions to optimise procedures in mines and quarries.

Fast Rock Segmentation

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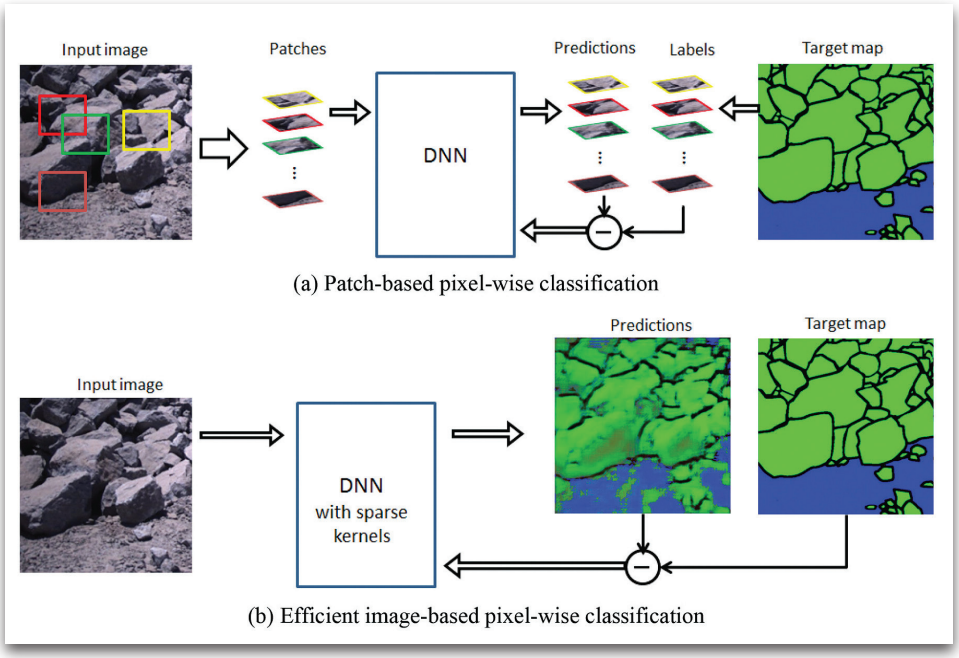

Figure 1. A comparison of patch-based scanning and the efficient image-based pixel-wise classification.

Using a roving camera and operator assisted analysis Maerz, Franklin, and Coursen (1987) measured the size distribution of the blasted rock and eliminated the need for manual sieve analysis. Since then, many others have introduced automated and manual methods for fragmentation analysis and improved upon existing approaches.

In image-based fragmentation, rock boundaries are identified in the image, and an image scaling is applied to transform rock pixel sizes into real-world dimensions. Usually, geometric references, such as regularly shaped objects (discs and basketballs), or the known size of an excavator bucket, are used to determine the proper scaling factor. In recent years, 3D-imaging and sensing have also been incorporated to improve rock delineation. Specific methods include using camera-laser combinations and stereo imaging to measure rock fragmentation on conveyor belts as well as portable fragmentation analysis devices with 3D-imaging sensors.

As mentioned above, a necessary step for image-based fragmentation analysis is accurate rock segmentation. This step can be automated, manual or a combination of both. The primary challenge in rock segmentation is having reliable segmentation unaffected by variations in lighting, reduced image contrast, and complex rock texture and presentation. In this article, we address this central problem of rock fragmentation, namely, the automatic segmentation of rock images. Reliably automated segmentation continues to be a challenge despite over 25 years of research. One reason may be the random nature of the fragmented material, which makes it more difficult to segment compared to other image segmentation processes, such as facial recognition, where there are standard features present in all the objects being segmented. A solution to this problem, however, is essential for any automated pipeline rock fragmentation analysis.

To perform segmentation, we use a particular type of deep artificial neural network as a pixel classifier. The label of each pixel (edge, rock, or fine) is predicted from raw pixel values within a square window centred on each pixel. The input layer maps each window pixel to a neuron. It is followed by a succession of convolutional and max-pooling layers which preserve 2D-information and extract features with increasing levels of abstraction. The output layer produces a calibrated probability for each class.

METHOD

Our solution to automatic rock segmentation is based on a Deep Neural Network (DNN) used as a pixel classifier. The network computes the probability of a pixel being a fragmented portion (pr), an edge of a fragmented portion (pe), or a region of fines (pf), using as input the optical image intensity in a square window centred on the pixel itself. An image is then segmented by classifying all of its pixels. The DNN is trained on a different stack with similar characteristics, in which rock segmentations were manually annotated.

In general, the DNN is initially configured and trained using training images that have been examined and labelled. For example, regions of images of fragmented materials may be marked to indicate whether the area is a fragmented portion, an edge of a fragmented portion, a void, or a region of fines. The images are then saved along with labelling information as labelled training images. It is desirable to have a sufficient

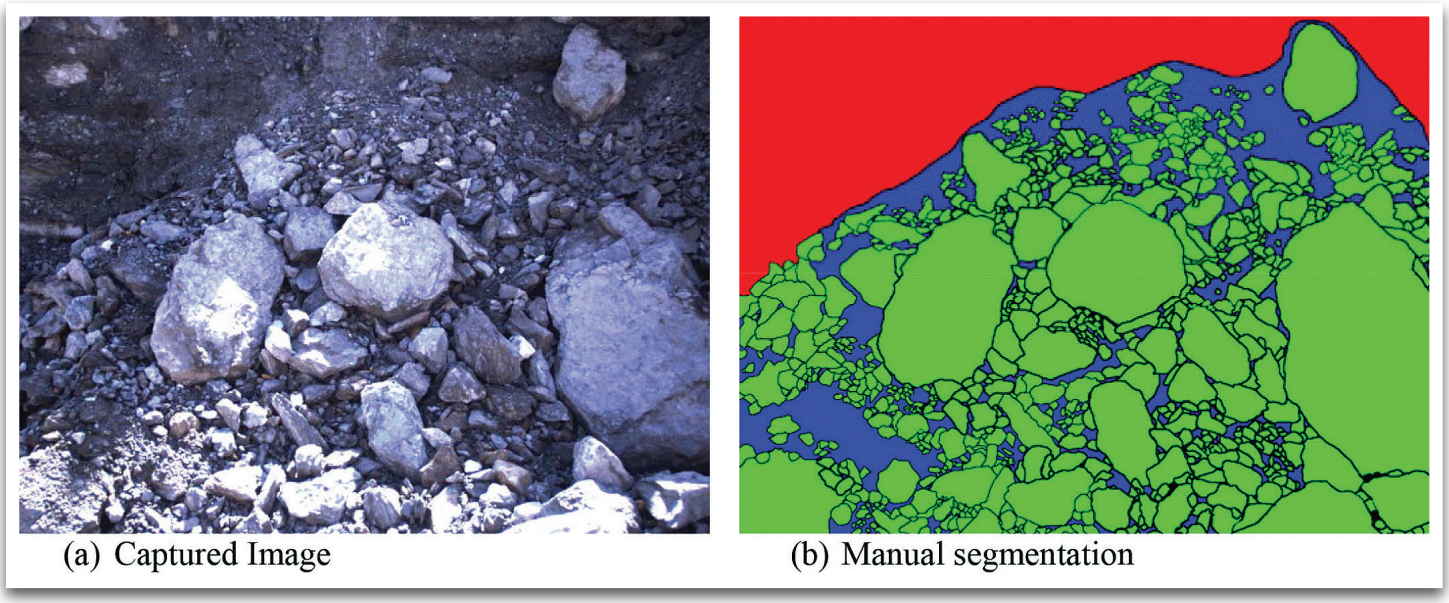

Figure 2. Sample image along with manual segmentation. In manual segmentation, green region shows fragmented material portion, black region shows edge of a fragmented portion, blue region shows fine regions, and areas outside region of interest are marked with red colour.

number of labelled training images under differing lighting and environmental conditions, differing scale, and differing types of fragmented material. A portion of the labelled training images may be used to train the network, and a further part may be set aside for validation of the neural network to evaluate training effectiveness.

EXPERIMENT

To evaluate the proposed method, we used 64 manually segmented images of 1,280 x 960 pixels. Figure 2 shows a sample captured image along with its manual segmentation. Green represents the fragmented material, black represents the edge of a fragmented portion, blue represents fines, and red represents areas outside the region of interest.

An automatic segmentation method was applied. First, the pixel classification using DNN was applied to these images. Then, watershed segmentation was applied on the probability maps which resulted from the pixel classification step, and closed boundaries were obtained. Then, automatic segmentation was compared to manual segmentation using two error metrics:

- Warping error: a segmentation metric that shows topological disagreements between automatic labelling and ground truth; it accounts for the number of splits and mergers required to obtain the candidate segmentation from ground truth.
- Pixel error: a segmentation metric that shows the number of pixel locations at which the automatic labelling disagrees with ground truth.

Percentage passing curves for the size distribution of rocks in pixel space were also obtained for the 64 test images.

Warping Error [$.10^{-6}$]	Pixel Error
44.3 ±15	(4.09 ± 1.4) %

Table 1. Average warping and pixel errors for the 64 test images

RESULTS

In the following section, we outline the results of the automatic segmentation algorithm compared to the labelled test data. We then demonstrate the performance of the automatic segmentation on images captured from a sieving test.

LABELLED DATA

Figure 3 shows the probability map for the sample image, along with the segmentation obtained after using watershed on the probability map. Once again, the green region shows the fragmented material; the black region shows the edge of a fragmented portion, the blue region shows fine areas, and red indicates areas outside the zone of interest. Figure 4 shows the warped automatic segmentation of the sample image to the ground truth. Table 1 shows the average warping and pixel errors for the 64 test images. Both warping and pixel errors are normalised by the total number of pixels within the image. Results

Fast Rock Segmentation

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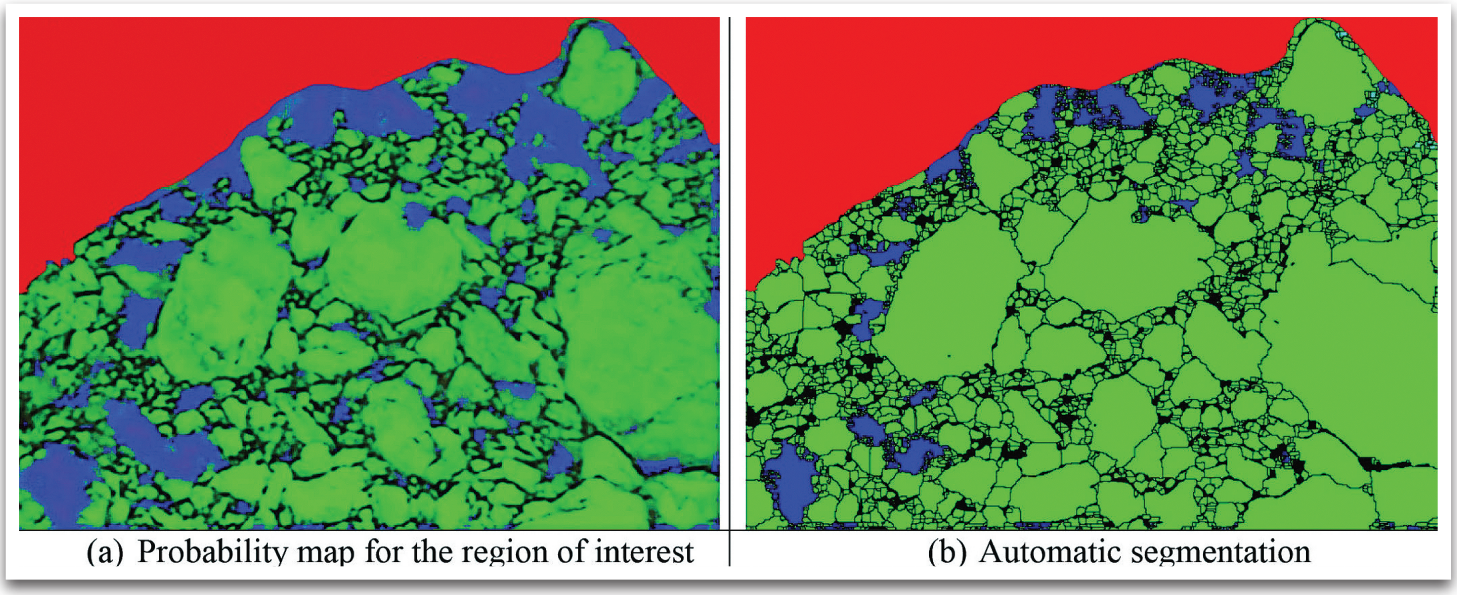


Figure 3. Probability map for the sample image, along with the segmentation obtained after using watershed on the probability map.

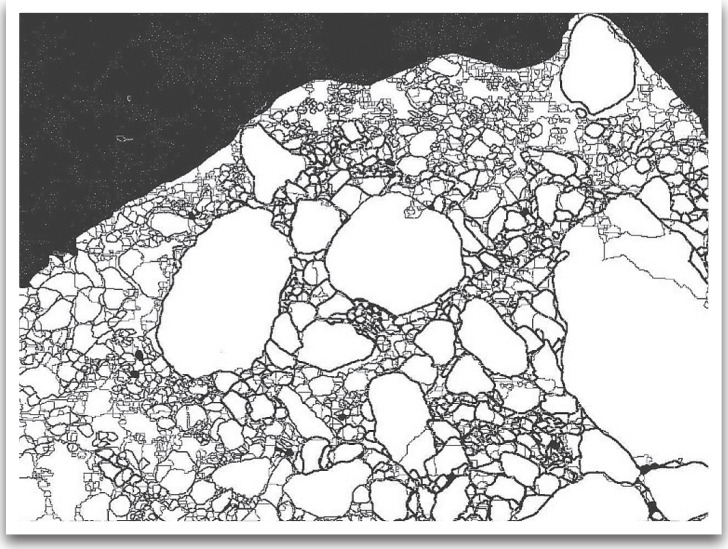


Figure 4. Warped automatic segmentation of the sample image to its ground truth.

show a difference of (8.48 ± 5.26) % between the ground truth and automatic segmentation.

SIEVED ROCK TEST

A test was organised in cooperation with Orica USA at a quarry in Texas. The goal of this test was to evaluate the performance of various automatic segmentation algorithms. This site was chosen as it had a mobile scalping screen, which sorted the material into piles of three sizes. Image data was captured as it was loaded out by an excavator. The collections produced by sorting the material were then measured and used as ground truth data for the test. Measurements were taken over two days, and the results were compiled. The charts in figure 6 show the percentage of undersize (sub 2 inches), in range (2 - 6 inches) and oversize (over 6 inches) particles as measured through automatic segmentation as well as manually surveying the sorted piles.

Figure 5. Mobile scalping screen used to sort material.

The automatic segmentation performed quite well, with some overestimation of oversize material. One possible reason for this may be that the images were captured before excavation. Through the excavation and sorting, process rocks that have been damaged due to blasting will break down further, reducing the amount of sorted oversize material.

CONCLUSION

This article presents a novel approach to rock segmentation, using machine learning techniques. This approach attempts to mitigate the challenges facing rock boundary delineation caused by variations in material texture, suboptimal lighting conditions, and the unknown size and shape of rocks. In the proposed technique, models were built based on training inputs, i.e. pixels within rock images, and used to make decisions for segmentation of test images. Results showed that fast and accurate automatic segmentation could be achieved using this technique. wn

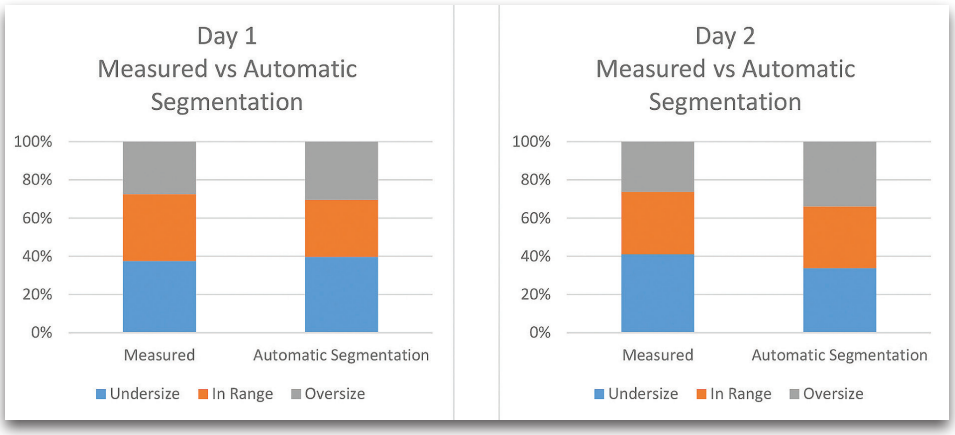
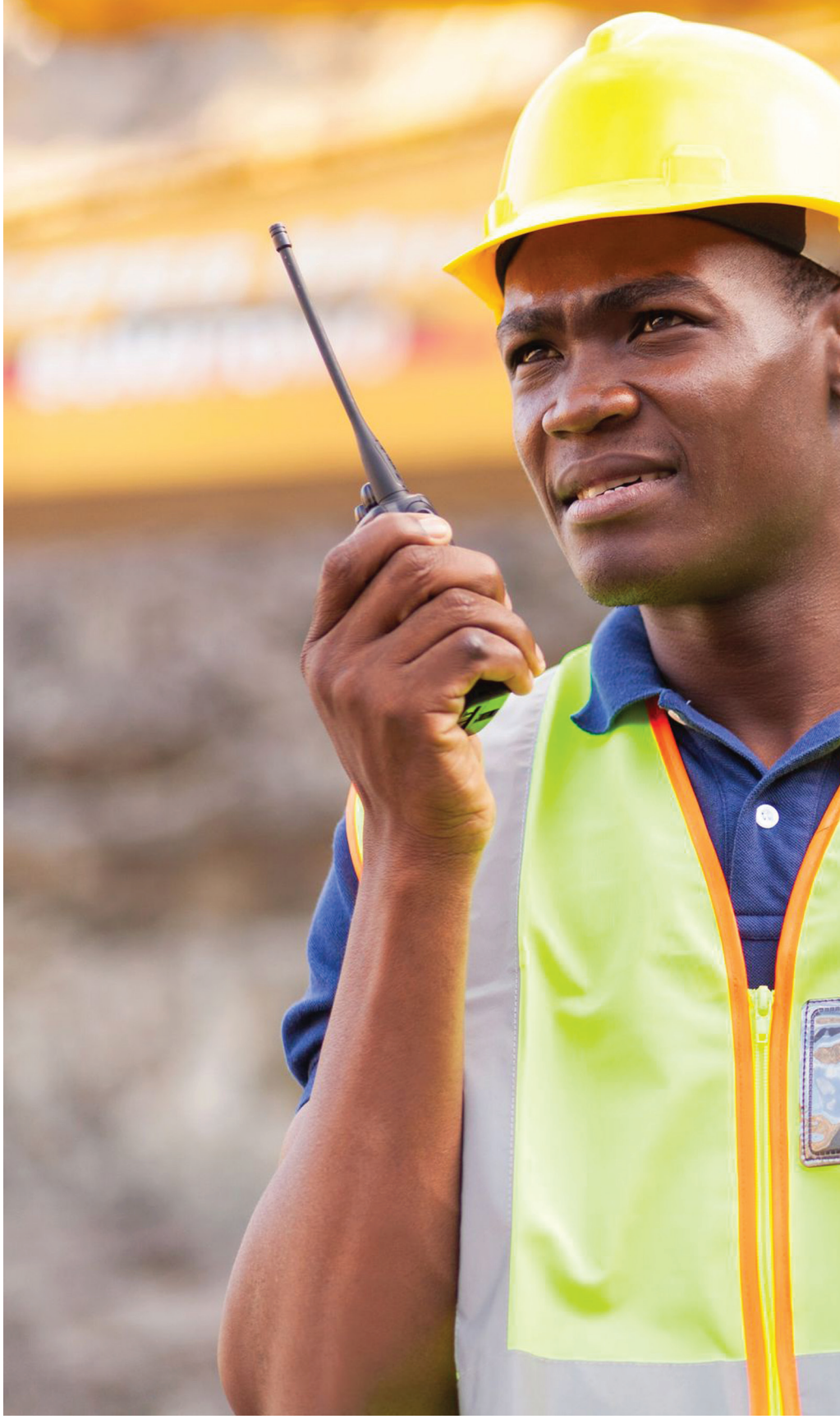


Figure 6. Results of comparing automatic segmentation with the output of mobile scalping screen over two days.

References available on request - ED

When was the last time we boarded an aeroplane and thought about what occurs in the cockpit? The activity that occurs before takeoff is meant to ensure that all the steps necessary are accomplished to provide a safe flight not only for all personnel but also the equipment. It's not that the pilots haven't done it a zillion times before. It is because they have and they also know that one missed step could lead to serious implications! Before engine start, the crew has completed, without exception, a Pre-operational Checklist.



In the 2011 seminal work on checklists, *The Checklist Manifesto: How to Get Things Right,* by Atul Gawande, the following observation by the author, even though he is a surgeon, could have been extracted directly from the mining industry.

"We don't like checklists. They can be painstaking. They're not much fun. But I don't think the issue here is mere laziness. There's something deeper, more visceral going on when people walk away not only from saving lives but from making money. It

Data Driven Reliability in Mining

BY | DALE R. EKMARK | SENIOR CONSU DCON

somehow feels beneath us to use a checklist, an embarrassment. It runs counter to deeply held beliefs about how the great among us—those we aspire to be—handle situations of high stakes and complexity. The great are daring. They improvise. They do not have protocols and checklists. Maybe our idea of heroism needs updating."

For those of you with any exposure to mining, or heavy industry for that matter, you will be able to relate to Mr Gawande's previous statement easily. Pre-operational checklists tended/tend to be "pencil-whipped", ignored, or sloppily done, with of course the rare exception that is completed accurately and with useful notes.
Why?

Mining Reliability

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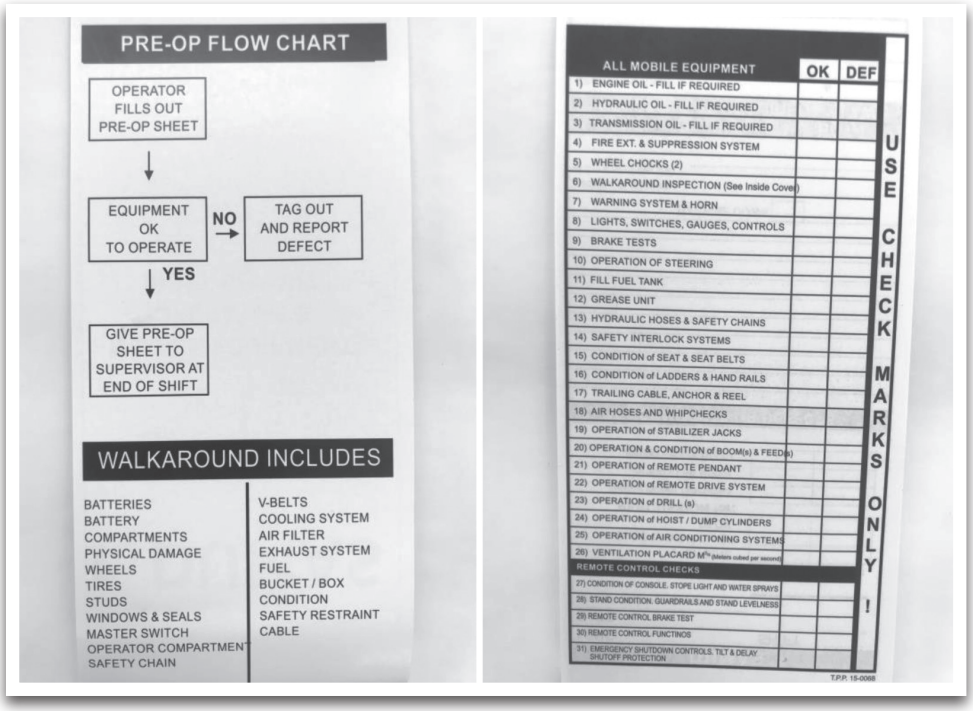

Classic Traditional Generic Underground Mining Pre-Operational Checklist

There are two, and probably many more, fundamental reasons. The first one is historical, the equipment was quite significant and didn't require extensive pre-operation inspection/tests. It was *"kick the tires and light the fires"*. Secondly, which was mentioned, the human ego got in the way of sound judgment. Without a clear understanding of the value of doing a pre-operational checklist, operators subjugated the task too menial importance, when the complete opposite was the reality.

With the history in mind, in many respects, mining has followed the similar path as aircraft, albeit slower. Instead of a B-17, we are concerned about a Jumbo Bolter, Remote Operated Scoop, Scissor Bolter, etc.

Again, Mr Gawande describes the mining industry at its current stage (substitute mining for aeronautics):

"Instead, they came up with an ingeniously simple approach: they created a pilot's checklist. Its mere existence indicated how far aeronautics had advanced. In the early years of flight, getting an aircraft into the air might have been, but it was hardly complicated. Using a checklist for takeoff would no more have occurred to a pilot than to a driver backing a car out of the garage. But flying this new plane was too complicated to be left to the memory of any one person, however expert. The test pilots made their list simple, brief, and to the point— short enough to fit on an index card, with step-by-step checks for takeoff, flight, landing, and taxiing. It had the kind of stuff that all pilots know to do. They check that the brakes are released, that the instruments are set, that the door and windows are closed, that the elevator controls are unlocked—dumb stuff. You wouldn't think it would make that much difference. But with the checklist in hand, the pilots went on to fly the Model 299 a total of 1.8 million miles without one accident. The army ultimately ordered almost thirteen thousand of the aircraft, which it dubbed the B-17. And, because flying the behemoth was now possible, the army gained a decisive air advantage in the Second World War, enabling its devastating bombing."

A similar scenario is rapidly unfolding in the world of mining and especially mobile equipment. The rate of technological advancement is quickly outstripping the capacity of operations and maintenance to keep pace. The traditional generic five-minute walk-around, pencil whipped, checklist pre-op of a piece of equipment is no longer valid and, to be honest, likely never was. To the left is a typical generic pre-op checklist that probably came into existence in the 1950's and is still used frequently in North America.

It would be normal to say *"Unfortunately, the equipment is becoming so complex …."* But that is not the case. Instead, *"Fortunately"*, mining equipment is becoming so complicated today that these traditional checklists are genuinely obsolete; however, they are still being used. Importantly, please note that this pre-op checklist is typically turned in at the END of a shift. In modern underground mining operations, most shifts are 12 hours, and even a small equipment fault that is uncorrected can develop into a major breakdown over a span of a single shift.

However, all is not lost in the world of mining. New leadership is entering the industry and "daring" to rock the pillars of a slow-to-change culture. One of those

mines is Goldcorp's new underground gold mine in Chapleau, Ontario, the Borden Mine. It is "Disrupting Mining" in a myriad of ways. As Canada's first entirely electric underground mine, it is on the vanguard of both technology and management operating systems (MOS) for the mining industry. The electrical mobile mining equipment, in many cases, is just out of the prototype phase and represents a quantum technological leap from traditional diesel-powered manual operated equipment.

It is not just the mobile mining equipment that has advanced. The advent of Industrial Internet of Things (IIoT) is now facilitating an enhanced underground asset health and maintenance management revolution. The Borden underground mine, like others, is now completely connected to the surface via high-speed Wi-Fi to the "cloud".

Luc Poulin, the Maintenance Manager at Borden, astutely recognised the opportunity and his vision is to completely automate and convert operator pre-op inspections from generic paper-based pencil whipping exercises, with a time latency of over 12 hours, to real-time data-driven tablet-based checklists. Defects will be noted, prioritised and an SAP notification will be automatically generated for the supervisor/planner to be able to plan and schedule the work directly from underground properly.

"Here at GoldCorp's Borden mine we are pushing the envelope of technology; we are 'Disrupting Mining'. We are Canada's first entirely electric underground mine and are incredibly dependent on early detection of defects of our advanced underground mobile fleet, to properly plan, schedule and execute our maintenance to safely and reliably achieve our production goals. Our first line of identification is from our operators during their pre-operational checklists. Together with IDCON, we are creating the next generation of digitally driven, real-time, operational pre-op lists to drive reliability." - Luc Poulin, Maintenance Manager, GoldCorp Borden Mine.

Stepping back to necessary reliability, the P-F Curve clearly illustrates the value of early fault detection. Early detection allows for proactive monitoring, proper planning & scheduling and ultimately effective, cost-effective maintenance which maximises uptime. The new tablet-based "Borden" underground, pre-operational checks harness not only the value of data-driven inspections but also the real-time capability of the internet,

Mining Reliability

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GOLDCORP
BORDEN GOLD

IDCON INC

Mobile –MEM OMNIA EV975 SCISSOR BOLTER
Borden EV975 BLO2 CMS300P
Pre-Operational Inspection Condition Monitoring Standards

BASIC PRINCIPLE

The **MacLean (MEM) OMNIEA EV Scissor Bolter** is a complete and complex bolting and screening vehicle for underground hard rock mining operations. It has been designed to facilitate safe drilling and screening functions during the mine development and rehabilitation services in drift/tunnel headings up to six meters (20 feet) high. The OMNIA is fully equipped as standard for the multi-tasking required in today's underground trackless mining environment. The Scissor Bolter is a complex machine with many user controls.
Powered by a Lithium-Ion Battery Pack, the electric driveline replaces the diesel engine used for tramming producing zero emissions, reducing operating costs and increased productivity. The batteries are charged during the tramming process, leaving the unit with full power to readily move to new work headings.

Benefits:

- Complete drift coverage from a single setup,
- New state-of-the-art Lithium-Ion battery operating system,
- Low cost dependable mine supply vehicle,
- Best of maintenance with electronic diagnostics, accessible grease points
- Superior traction due to four-wheel drive

Applications:

1. Best suited for installation of ventilation ducting, electrical reticulation, and piping for air and water services,
2. Rehabilitation projects are conducted safely and efficiently from the level work deck, elevated to a comfortable work height.

The inspection should be done first, with the loader de-energized and shut off /made safe according to local company and government regulations

Additional pre-operational checks must be performed with unit energized
Due care must be insured to perform this safely.

Disclaimer: Please refer to the current version of the
MacLean OMNIA EV Scissor Bolter Operator Manual that supersedes this document

It is the responsibility and obligation of Goldcorp Borden Mine to ensure compliance to the various sections in Regulation 854 (Mines and Mining Plants) under the Occupational Health and Safety Act (OHSA) of Ontario. In addition, current operations/maintenance manuals of the OEM supersede the CMS and Pre-op Checklists."

CMS 300P DRAFT V2
1

Figure 1 - A concise operational reference document.

which not too long ago was not possible underground. With the increasingly sophisticated equipment, real-time monitoring of assets and assessing the operator inspections/machine-generated data is paramount to the early detection of problems for corrective maintenance before catastrophic failures.

Together with IDCON, Inc., the Goldcorp Borden Mine reliability journey commenced in early 2018. Recognizing that, to capitalise on the opportunity, not only must pre-operational checklists become data-driven, operators also need to be extensively trained to understand what a pre-operational check is and actually why they are doing it. Recognizing that reliability is a shared responsibility between maintenance and operations, the approach undertaken included creating an operator reference guide called "Pre-operational Condition Monitoring Standards" (CMS).

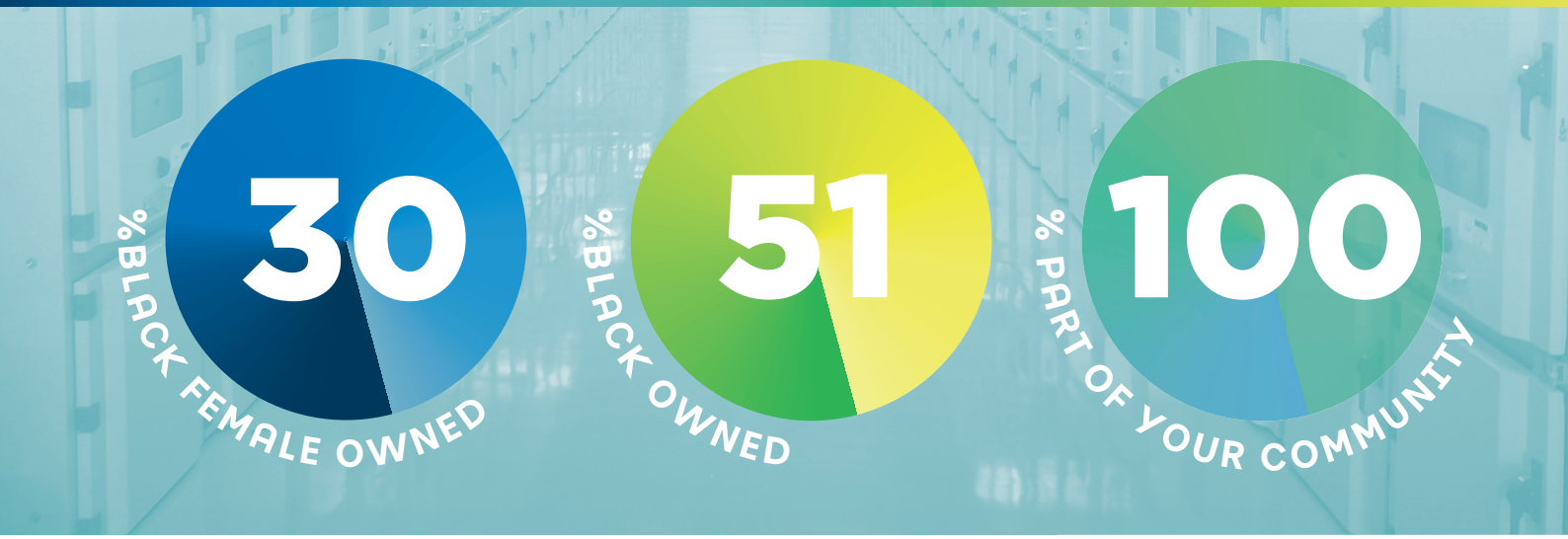
Figure 1 depicts a concise operational reference document that doesn't supersede Ordinary Equipment Menu manuals but complements them.

The Condition Monitoring Standard is then converted to the new data-driven pre-operational checklists that capitalise on the concept of Operations led reliability

In an industry that not too long ago was unfairly labelled as, "Dark, Dirty and Dangerous" and where Maintenance and Operations were "opposing" forces; the leadership of Goldcorp's Borden Mine have recognised that Safe Reliable Operations is a compelling shared vision for excellence for the entire organisation. This high tech revolution has taken the mine by storm and not only will it enable dramatically improved reliabilities and cost efficiencies but the collateral benefit is a safe operation. This all begins with leadership and the daily commitment to a thorough and accurately completed pre-operations inspection.

Pre-operational checklists are not "new", "sexy" or exciting. What they are is the leading foundation of a safe, highly efficient, reliable and cost-effective mining operation! wn

Proconics being Brilliant in Africa



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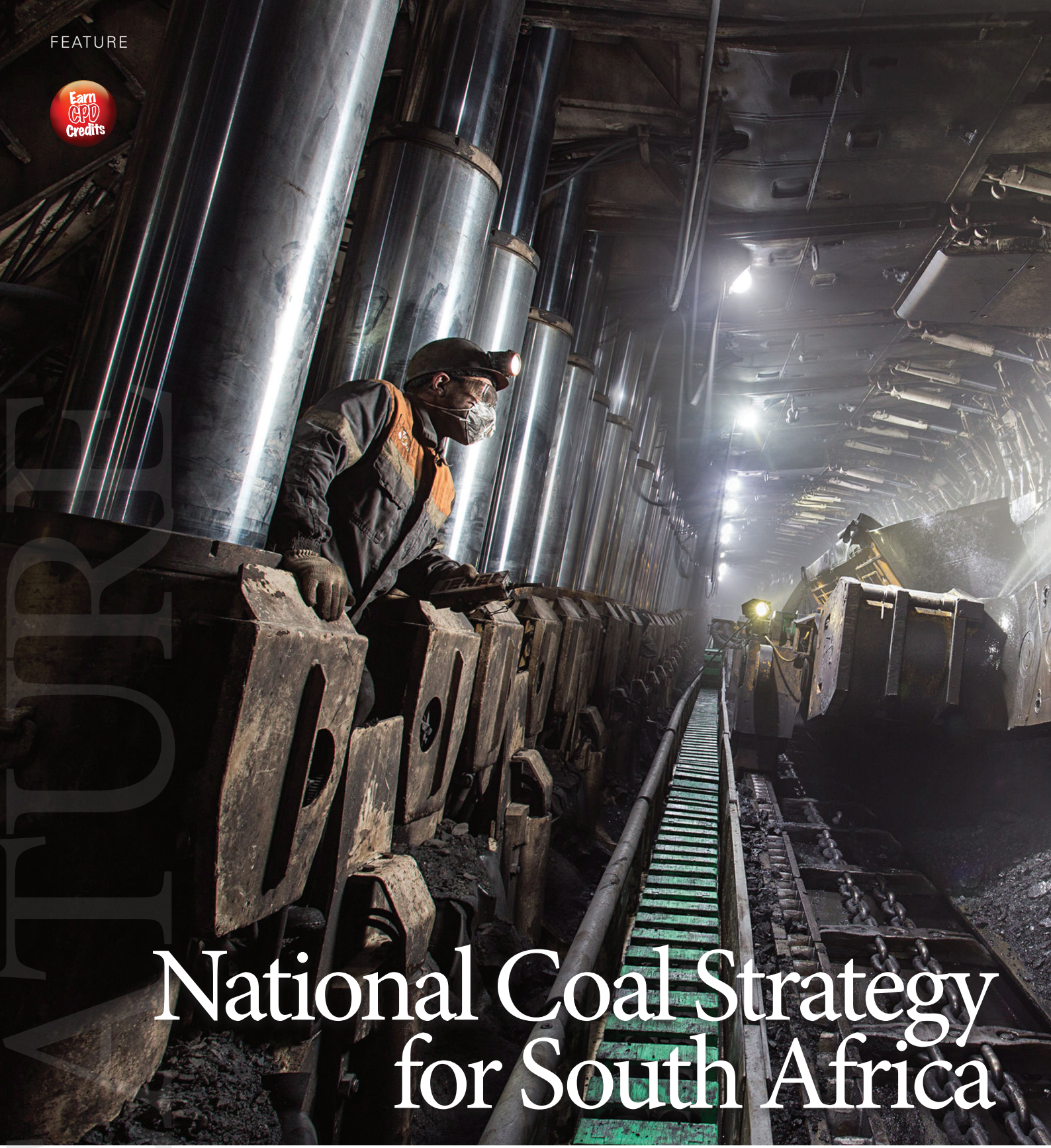

National Coal Strategy for South Africa

The Chamber of Mines Coal Leadership Forum, consisting of coal executives, commissioned a report to determine what needs to be done to increase the profile of the coal mining industry in the face of seemingly ineluctable negative public opinion around the use of coal in industrial processes.

Excerpt of the 2018 National Coal Strategy for South Africa, published by the Chamber of Mines, of South Africa.

For the complete pdf document, please send an email to minx@saiee.org.za with "National Coal Strategy" in the subject field.

Negative views on coal and its impact on the environment have resulted in a precipitous decline in the use of coal by the major economies of the world. Because of coal's contribution to Greenhouse Gas (GHG) emissions, many jurisdictions including South Africa, have put in place strict environmental laws which have affected demand for coal.

This report draws attention to the three industries and sectors that will be adversely affected by the implementation and enforcement of strict environmental laws in South Africa: they are the electricity sector; the liquid fuels manufacture sector; and the iron and steel industry. Together, these three sectors account for more than 80% of domestic coal demand concerning the value and approximately 70% regarding volumes.

Currently, the use of coal in the electricity sector is the cheapest baseload power generation technology. This is supported by the Department of Energy's Integrated Resource Plan (IRP 2016) which shows that the Levelised Cost of Electricity (LCOE) across the various coal technologies, is lower than renewables. If battery technology for renewables is taken into account, the LCOE increases significantly.

When it comes to emissions arising from coal powered generation, new technologies such as High Efficiency, Low Emissions (HELE) and Carbon Capture and Storage (CCS) emissions and other pollutants are reduced quite drastically. Japan and China have employed the HELE technology to great success. The essence of the coal industry's argument in respect of which electricity generation technologies should form part of the country's energy mix is that

2018 Coal Strategy

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the final decision should be based on the 'least cost option'.

For the other two industries that are significant users of coal, namely liquid fuels manufacture and the basic iron and steel industry, it is likely that CCS could help reduce carbon emissions for now. However, this technology is currently not a commercially viable option for most industries.

The report also considers the export sector. Data presented in the report shows that there has been a total shift from European markets to Asia. Further, it shows that China is South Africa's chief export market and it turns out that India accounts for almost half of the country's total exports concerning volumes. The Chamber's viewpoints towards India continuing on this trajectory, not least because the country seems to have institutionally patronised the coal resource through the Ministry of Coal.

To better understand the relevance of the coal industry in South Africa the report presents data on employment (direct and indirect), production, productivity, the cost structure of the trade, profitability and investment. Among other things, the report shows that:

- indirectly, the coal industry is responsible for creating and sustaining over 170,000 jobs outside the industry;
- for most of the period between 1980 and 2015, increased labour productivity accounted for an increase in coal production (in volumes);
- transport and storage costs account for more than 50% of total industry costs (excluding value add);
- as a share of total GDP value-add, compensation of employees outpaced net operating surplus/profits for most years between 1995-2015; and
- coal export prices are the leading indicator of net investment. In other words, a sustained increase in export prices is soon followed by higher net investment.

The latter may not seem to be important when considering that regarding volumes, exports account for about 30% of total sales. Regarding value, exports make up approximately 45% of total earnings.

The report culminates with the presentation of domestic constraints including issues and factors that are likely to result in reduced demand for, and supply of coal. The restrictions are instrumental in developing the four scenarios (2016-2050) outlined below:

- **Scenario 1:** Coal extinguisher (-1%) – In this scenario, total coal demand declines annually by an average of 1%. The primary assumption is that nuclear power and renewables have supplanted coal as the main primary energy source. Environmental and water regulations stifle coal use.
- **Scenario 2:** Trudge along (1%) – An essential assumption in this scenario is that growth in total coal demand remains positive, but is lower than the 2.3% average growth experienced between 1980 and 2016. The key assumptions underpinning this scenario are that carbon tax is introduced and that access to land for mining purposes becomes a contentious issue. This is balanced by the fact that renewable technologies lose political support and that the development of battery technology occurs at a slow pace.
- **Scenario 3:** Status quo (2.3%) – Between 1980 and 2015, growth in coal production averaged 2.3%. This scenario assumes that clean coal technologies gain ground while everything else remains the same. For example, there is no carbon tax and Eskom's procurement policy does not change.
- **Scenario 4:** Firelighter (5%) – This scenario assumes a significant leap in clean coal technologies and an increase in export demand leading to increased investment. Government policy is also considered to be supportive of the industry.

Corresponding to each scenario, actions that need to be taken by stakeholders to either mitigate the impact or take advantage of the opportunities presented by each future, are included.

Coal is currently the most vital energy source in the world after oil. It is also one of the cheapest and most abundant energy carriers. Before the discovery of coal in the 16th century in England, peat was used mainly in the Netherlands where it brought about the Dutch Golden age – a period of economic prosperity. The amount of energy present in peat is minimal compared to coal, and as such, the discovery of coal resulted in it becoming the most abundant energy source. In England, the steep price of firewood, which had been a significant energy source until then, hastened the shift to coal. The discovery of cheap coal energy spurred the industrial revolution in Britain, starting with its use in the mining sector, then the transport sector, later for industrial processes, and then for the generation of electricity. As an electricity source, coal power and the steam engine were first used to pump water out of coal mines.

As an enabler, coal power resulted in the

introduction of many new materials such as synthetic abrasives, chlorine, aluminium, stainless steel, and tungsten. These, in turn, opened the way for innovations such as high-speed grinders, chlorinated water, PVC, incandescent lamps, X-rays, and the aircraft industry.

Coal's share in the global energy mix has steadily soared. Even as the global economy suffered one of the most notable energy price shocks, coal has remained resilient. In 1973, the share of coal in the worldwide energy mix was 24.5%, the equivalent of around 3Mt, while oil was 46.2%. By 2014, coal's share had increased to 28.6% (or around 8 Mt) while oil's stock had declined significantly to 31.3%.

In modern times, coal power has played an essential role in improving the welfare of communities across the globe. In China, for example, coal power has managed to lift millions of people out of electricity poverty. To date, out of a population of 1.3 billion people, there are only a mere 3 million people who do not have access to electricity in China.

Coal as an energy source faces many challenges not least among them the fact that, as a significant contributor to GHG emissions, coal is responsible for environmental degradation.

At an international level, governments have developed and rectified legislation to cut down on the use of coal in electricity generation. As a result, environmentally-friendly technologies are subsidised with the hope that soon they will replace coal in the process of generating electricity. In countries such as the US, the UK and Germany, coal power has declined significantly having been replaced by nuclear power and renewables.

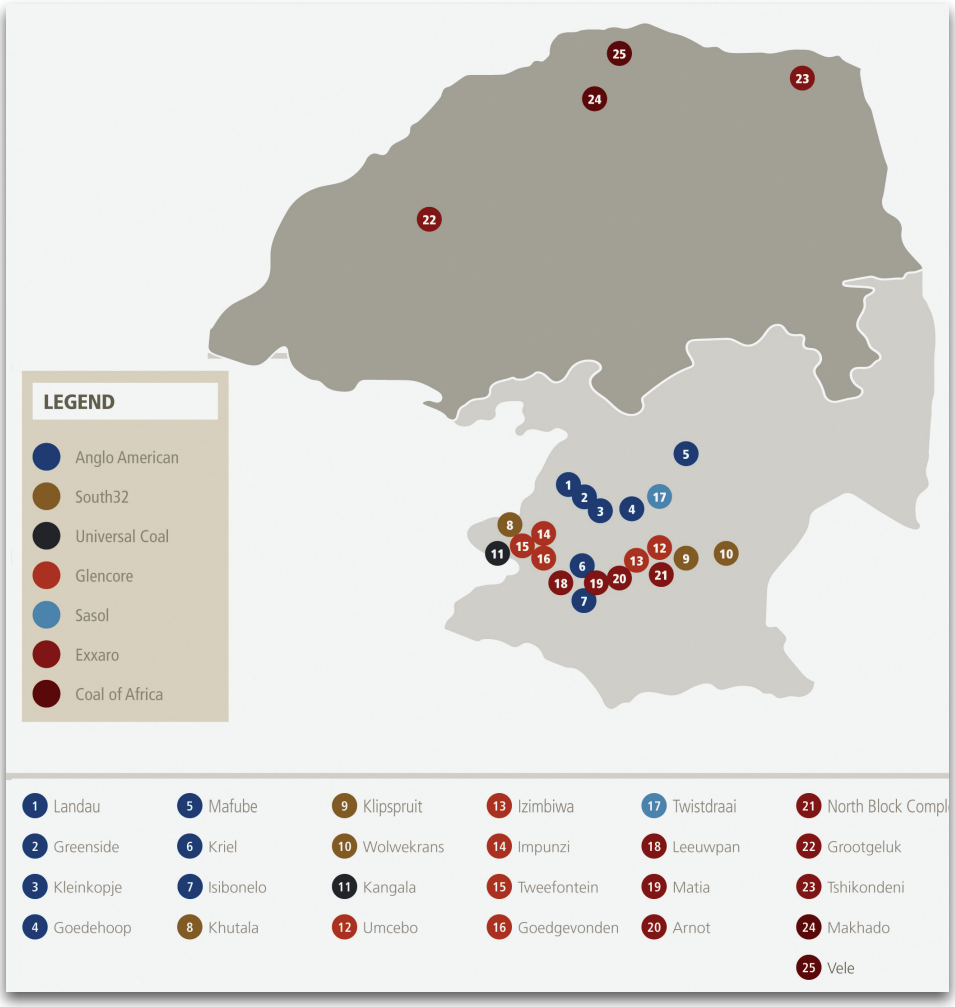

Figure 1: Location and geology of coal resources in South Africa

The South African government, too, has ratified the Paris Agreement, which entered into force on 4 November 2016, signalling that government is committed to addressing the challenge of climate change. Government, through the Department of Energy (DoE), intends reducing the share of coal-generated power in the country's electricity mix from 82% in 2016 to 31% in 2050 as outlined in the Integrated Resource Plan (IRP) 2016.

However, coal and nuclear power will continue to play an essential role in the economy as the IRP 2016 adds 6.3GW of electricity to existing generation consumption levels which will have come from coal-fired power plants.

In South Africa, the discovery of coal dates back to 1879 when George William Stow, on his second attempt after an unsuccessful prospecting bid in the area around Bethlehem (Free State), found commercially viable deposits in the Transvaal. Without adequate transport

2018 Coal Strategy

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infrastructure, the Orange Free State Government, which had commissioned Stow, decided not to develop the find. However, Stow and his colleagues developed the coal find and used wagons pulled by oxen to transport it to Kimberley.

Figure 1: Location and geology of coal resources in South Africa
The map below illustrates the geographic locations where most of South Africa's coal deposits are located – mainly in Mpumalanga and Limpopo. Coal can also be found in Kwa-Zulu Natal and the Free State provinces. South African mines make use of open-cast and underground mining. Figure 1 also presents the leading coal mining companies across the industry.

COAL HAS THREE MAJOR USES

ELECTRICITY GENERATION

As a source of energy, the global share of coal used in electricity generation has risen slightly from 38.3% (2,348.2TWh) in 1973 to 40.8% (9,716.9TWh) in 2014.

In spite of environmental concerns and legislation restricting the use of coal in electricity generation and industrial processes, coal continues to be an essential energy source across the globe.

INDUSTRIAL PROCESSES:

Many industries use coal and coal by-products. The cement/concrete and paper industries burn large amounts of coal to produce heat. Coal is also used in the steel industry. Steel plants use coking coal in their furnaces to process iron ore into iron to make steel. The high temperatures created by burning coke give steel the strength and flexibility needed for infrastructure projects such as bridges and buildings, the automobile sector and others.

MANUFACTURE OF GAS AND LIQUID FUELS:

Coal can be turned into gases and liquids (synthetic fuels) which are used as fuels or processed into chemicals to make other products. The fuels are made by heating coal in large vessels. These fuels produce fewer air pollutants when burned than burning coal directly.

THE MARKETS FOR SOUTH AFRICAN COAL

This section presents historical trends in coal production, domestic and export markets and prices. The starting point of most of the data is 1970, before the oil price shock of 1973, and runs until 2016. The domestic and export markets for South African coal have developed over time, each with their dynamics. In 2016, South Africa exported 28% (68.9Mt) of its coal by volume and sold 72% domestically. By value, exports were worth R50.5 billion (45% of the total) and domestic sales R61.5 billion (55%).

	1973	2014
Coal	24.5	28.6
Biofules and waste	10.5	10.3
Natural Gas	16.0	21.2
Oil	46.2	31.3
Nuclear	0.9	4.8
Hydro	1.8	2.4
Other	0.1	1.4

Table 1: World fuel share of totaly primary energy supply (%).

	1973	2014
Coal	38.3	40.8
Natural Gas	12.1	21.6
Oil	24.8	4.3
Nuclear	3.3	10.6
Hydro	20.9	16.4
Other	0.6	6.3

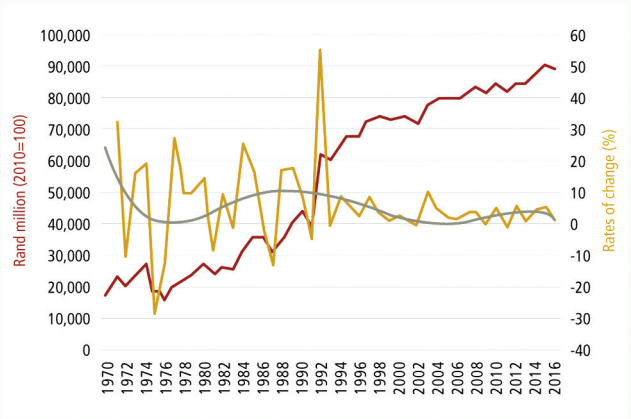
Table 2: World fuel shares of electricity generation (%)

Globally prices are determined by demand and supply and, unlike other energy markets such as oil, the market is not organised into cartels. Eskom sets the benchmark price for domestically-consumed coal.

As an abundant resource relative to other energy carriers, coal is more affordable. Figure 4 charts the price of coal and natural gas per one million British Thermal Units from 2000 to 2015.

Eskom mainly determines the domestic price of coal and historically it has always been lower than the export price. Figure 6 compares the local and export prices of coal while figure 7 illustrates that the price offered by Eskom is less volatile compared to the export price.

Between 1971 and 2015, export prices grew by an average of 15.3% per year compared to 13.6% for local sales; between 1990 and 2015 export prices increased annually by 11.9% while domestic sales

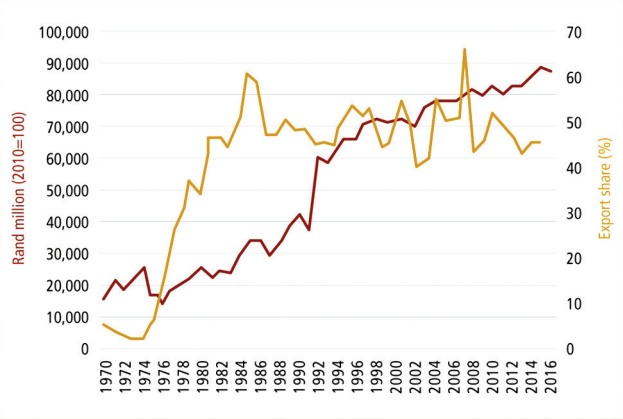


Sources: StatsSA, DMR, Quantec, 2016

Coal mining production grew by 1.2% between 2000 and 2016, to reach a level of R118 billion in 2016. This represents value add of R72 billion or 24% of the mining sector.

Importantly, coal mining production was not seriously affected by the commodity cycle downturn, with fairly stable growth since 2000 reaching a peak in 2015.

Figure 2: Coal mining production.



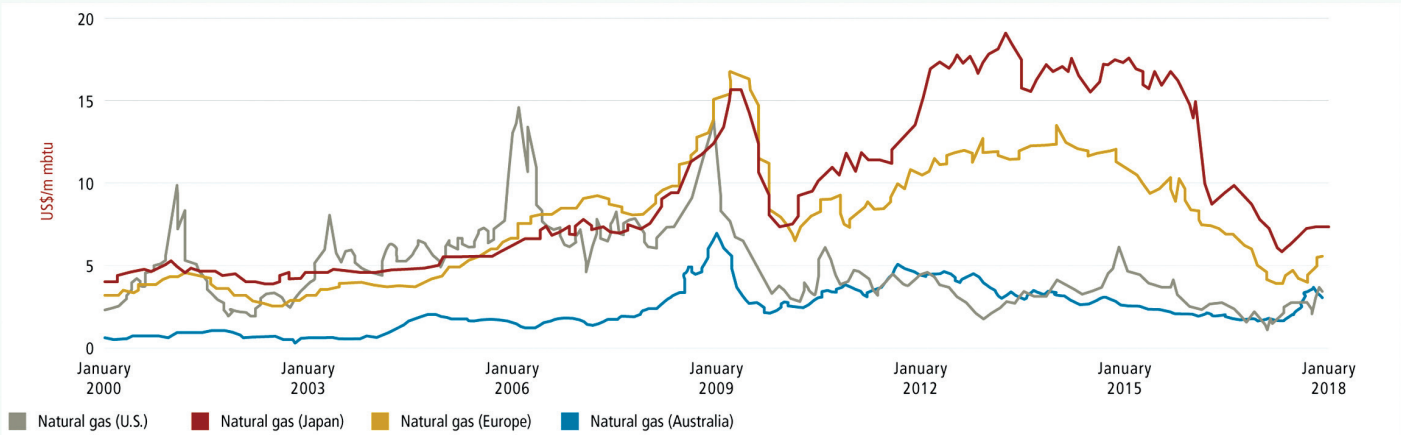
Sources: StatsSA, DMR, Quantec, 2016

The export market for coal has been a major driver for the South African coal mining sector.

The share of exports rose rapidly during the 70s reaching a peak in 1985, and again in 2008.

Export price trends and the continual weakening exchange rate had a large impact on coal mining in South Africa.

Figure 3: Coal mining production and export share.



Source: World Bank Commodity Markets Outlook

Figure 4: Coal and natural gas prices

recorded increased by 11.2%; and between 2005 and 2015, coal export prices increased by 13.8% while rates for domestic sales increased by 12.1%.

The most significant increase in export prices was an increase of 105% to R735.64/Mt recorded in 2008. In the same year, local prices increased by only 42.3% to R150.7/Mt.

In 2016, for the first time since 1970, the local price reached 50% of the export price. The historical average (1970-2015) is 35.2%.

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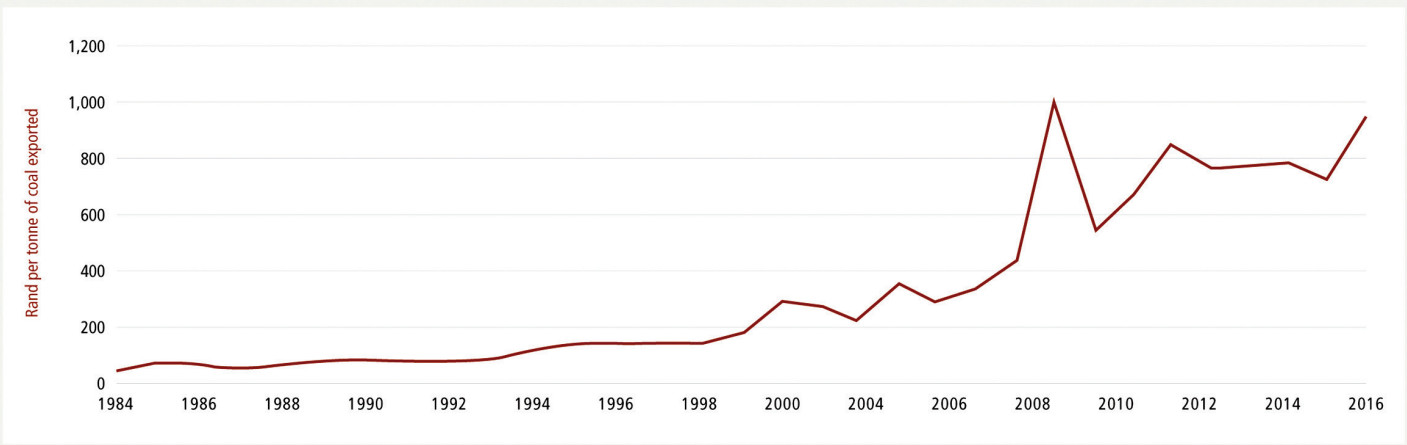
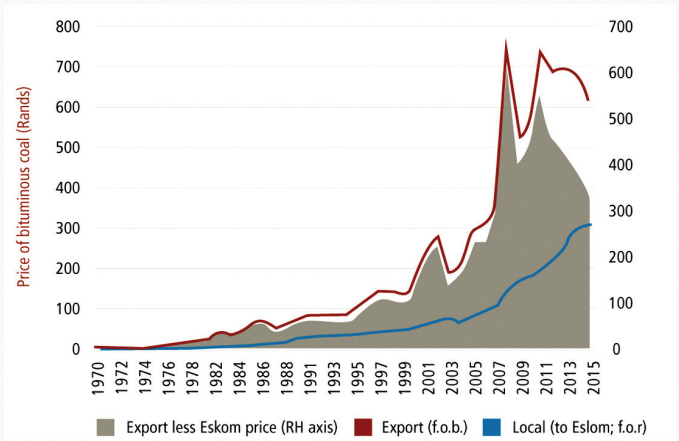


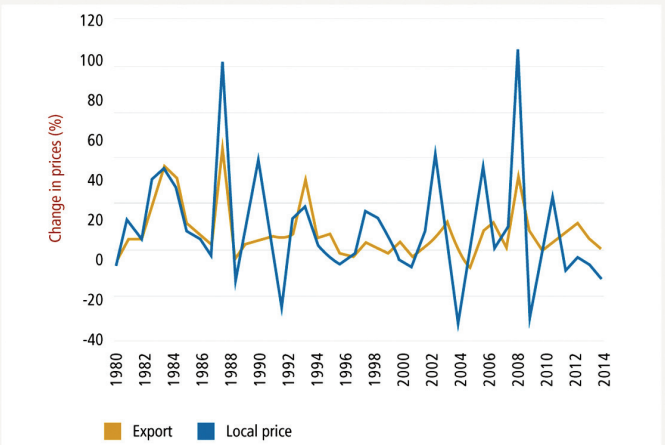
Source: World Bank Commodity Markets Outlook

Figure 5: Rand coal prices per tonne at Richards Bay



Source: Department of Energy Price Report

Figure 6: Price of bituminous coal in South Africa



Source: Department of Energy Price Report

Figure 7: Change in coal price (%)

GLOBAL DYNAMICS

– Reserves, Production, Consumption, And Implications For South African Coal Exports

Five questions are of concern to us:

- What is the extent of the coal resource globally?
- Which countries are the primary producers and consumers of coal?
- What is the future of coal consumption globally?
- What are South Africa's export markets and what are the future consumption levels going forward in those markets?
- What factors are behind the rise and decline of coal consumption in some of South Africa's export markets?

The International Energy Agency (IEA) estimates that the world's recoverable coal reserves are 888.9 billion tonnes (IEA, 2016). Globally five countries have nearly 73% of the world's recoverable coal reserves. Ranked third concerning coal resource endowments, China is by far the world's leading producer of coal, which is used mainly in power generation. It is followed by the US, which in recent years has closed hundreds of coal mines for many reasons. Chief among these is an ageing fleet of coal power plants and the country's international commitments to curb GHG emissions.

China is also the leading consumer of coal and has had to rely on imports to satisfy its coal requirements. The US, on the other hand, is self-reliant on coal and government policy under the Obama administration was directed at the country wean itself off of coal dependency in power generation. India is the second largest consumer of coal, which it also uses predominantly to generate electricity.

Of the ten major global consumers of coal, China and India are net importers. Their combined consumption is more than the sum of the other eight countries on the list (Table 3). Other top 10 net importers of coal are Japan, South Korea, Taiwan, Germany, Turkey, UK, Malaysia, and Thailand.

THE FUTURE OF COAL CONSUMPTION GLOBALLY

The IEA predicts that demand for coal for power generation will decline from 41% in 2014 to 37% in 2021. Figure 8 provides consumption forecasts of primary energy sources going forward. Coal and oil are projected to decline, with the latter dropping significantly.

CURRENT EXPORTS OF SOUTH AFRICAN COAL

Historically, South Africa exports about 30% of its total domestic coal production. In 2016, this was equivalent to 69Mt. On the other hand, export sales have traditionally accounted for between 40 – 45% of total coal sales, highlighting the importance of the export market.

Total exports were valued at R50.5 billion in 2016 of a full sales figure of R112 billion. Coal is, therefore, an important foreign exchange earner. Most South African coal exports are destined for India, which takes up about 45% of coal export volumes.

India started to become an essential market for South African coal in 2007 when sales volumes suddenly went up from 3% (2006) of total exports to 13%. South Africa's traditional coal export market used to be Europe, in particular, the Netherlands, Belgium, and the UK. After 2000 this changed when the Kyoto Protocol, which sought to enforce the mandatory reduction of GHG emissions. The Kyoto Protocol was adopted in 1997, but it was not until 2005

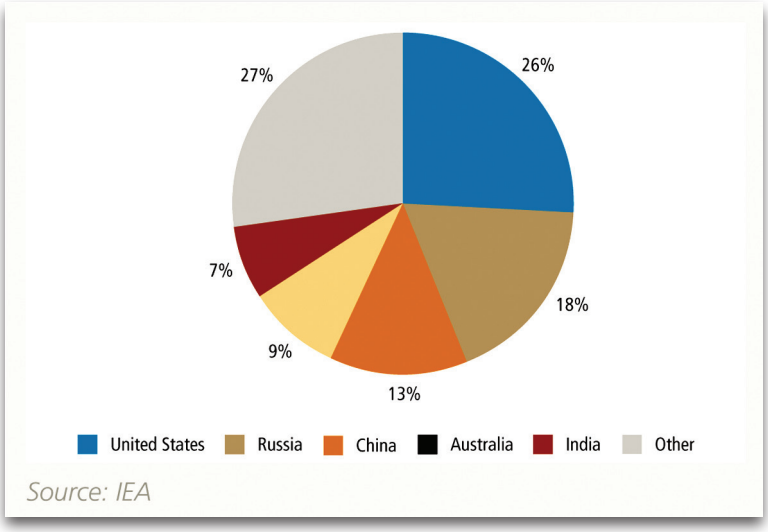


Figure 8: Global recoverable coal reserves in 2016 (%)

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WORLD RANKING	PRODUCTION (MILLION METRIC TONNES OF OIL EQUIVALENT)								
	1981	1990	2000	2005	2010	2012	2013	2014	2015
World	1863	2274	2326	3034	3628	3930	3986	3898	3830
1. China	311	540	707	1242	1665	1874	1895	1864	1827
2. US	463	566	570	580	551	518	501	508	455
3. India	64	106	152	190	252	255	255	271	284
4.Australia	65	109	167	206	241	250	268	287	275
5. Indonesia	0	7	47	94	169	237	276	282	241
6. Russia	n/a	186	121	136	151	168	173	177	184
7. South Africa	75	100	127	138	144	147	145	148	143
8. Colombia	3	13	25	39	48	58	56	58	56
9. Poland	103	100	72	69	55	58	56	58	56
10. Kzakhstan	n/a	57	32	37	47	52	51	49	46
WORLD RANKING	**CONSUMPTION (MILLION METRIC TONNES OF OIL EQUIVALENT)**								
World	1836	2243	2379	131	3634	3814	3891	3911	3840
1. China	303	526	701	1318	1743	1923	1964	1949	1920
2. India	64	110	164	211	293	330	356	389	407
3. US	407	483	569	574	525	438	455	454	396
4. Japan	65	78	95	114	116	116	121	119	119
5. Russia	n/a	182	106	95	91	98	91	88	89
6. South Africa	51	67	75	80	93	88	89	90	85
7. South Korea	15	24	43	55	76	81	82	85	84
8. Indonesia	0	3	13	24	39	53	58	70	80
9. Germany	144	132	85	81	77	80	83	79	78
10 Poland	91	78	56	55	55	51	53	49	50

Table 3 : Coal balances (top 10 producers and consumers)

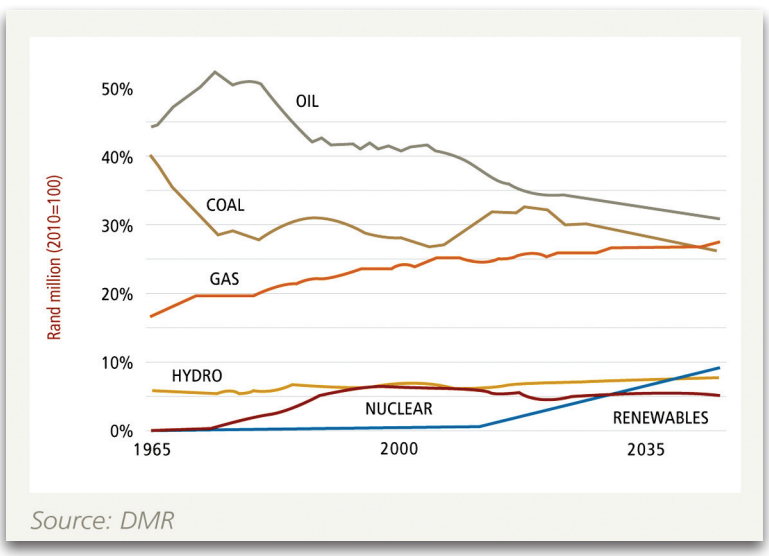

Figure 9: Exports of coal by volume and value

that countries, mainly those in Europe, took practical steps to implement the Protocol. European countries started reducing coal imports from then.

Table 4 shows the outcome as follows:
While the Netherlands consumed more than 20% of South Africa's coal export volumes in 2011, this went down to approximately 5%. Except for 2013 and 2014, the trend points to the Netherlands having drastically reduced its coal imports from South Africa. The UK reduction appears sudden, from 17% in 2004 it has averaged 1% since 2009. France, Spain, Denmark, Germany have had similar reductions in coal imports. Italy seems to be holding up, but the trend also indicates a decline. China, which used to import a significant amount of South African coal, has taken drastic measures to reduce CO_2 emissions. For that reason, China has been closing some coal mines and restricting operating days of state mines from 330 to 276 per annum.

FUTURE DEMAND FOR SOUTH AFRICAN COAL EXPORTS

India, currently South Africa's biggest coal export market, has agreed to voluntarily reduce the GHG emissions intensity of its GDP by 20% to 25% from 2005 to 2020.

Thus far, this has not affected South African coal exports to the country, which have grown to almost half our total coal exports in revenue terms.

Indications are that India's coal demand will continue to increase in the foreseeable future for several reasons:

- Electricity supply in India has still not kept up with growth in demand;
- India's electricity market is dominated by coal, which accounts for more than 75% of total electricity generation. India is the world's third largest coal energy user after China and the US;
- India's Ministry of Coal is the custodian of coal resources in the country. This institutionalisation of coal could ensure the resource's use in the future. India also has a Ministry of Power, a Ministry of

MAJOR SOUTH AFRICAN COAL EXPORT MARKETS (% SHARE OF TOTAL COAL EXPORT EARNINGS)													
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mozambique	2	2	2	2	1	2	2	4	3	2	2	1	1
China	0	0	0	0	0	1	9	18	16	16	4	0	0
Taiwan	2	0	0	1	0	3	4	5	6	8	2	2	1
South Korea	0	0	0	0	1	1	3	5	2	0	0	0	4
India	1	5	3	13	13	29	33	24	29	27	37	42	45
Pakistan	0	0	0	2	1	2	2	1	1	3	5	5	7
Malaysia	0	0	0	1	3	2	4	4	4	3	2	1	2
Israel	10	7	6	6	6	7	5	4	7	4	3	4	2
Turkey	2	2	4	2	2	2	3	4	4	4	5	6	3
UAE	0	0	0	1	1	1	3	2	3	3	3	2	3
Denmark	2	2	4	3	2	1	1	2	1	0	1	0	1
France	5	7	6	4	4	3	2	2	1	2	1	1	1
Italy	10	8	7	8	7	7	4	5	5	3	2	5	4
Netherlands	24	22	25	23	19	14	5	4	5	10	14	3	4
Spain	13	12	12	14	10	8	4	3	3	3	4	3	1
UK	17	16	13	6	6	1	1	1	1	1	1	0	0
Germany	2	1	1	1	1	1	1	2	0	0	0	0	0
Growth in earnings (5, year on year)	16.3	31.6	1.2	13.8	63.6	-8.7	13.1	35.2	1.1	2.2	2.3	-4.6	8.7

Table 4: Major South African Coal Export Markets

Petroleum and Natural Gas, a Ministry of New and Renewable Energy, and a Department of Atomic Energy.

Export growth markets seem to be in Asia, in countries such as India, Pakistan, Malaysia, Taiwan, and Bangladesh, not all of which are included in table 4. South Korea seems to present the potential for further export growth for South African coal. This opportunity needs further investigation to ascertain the possibility that this market offers. There is no scope for further growth in Europe (more precisely countries in the European Union) because of environmental laws.

While there is potential in Sub-Saharan Africa for export growth because of electricity shortages, the dearth of investment and investment finance is unlikely to increase appetite for coal.

An export risk factor, other than environmental laws, is technology. South Africa's current and potential export markets are on a big push to build HELE power generation plants.

This technology requires high-quality coal, with which some of the country's competitors such as Australia are endowed.

SUMMARY

There had been a total shift from European markets to Asia; and that contrary to popular belief that China is South Africa's chief export market, it turns out that India accounts for almost half of South Africa's total exports concerning volumes. The Chamber's viewpoints to India are continuing on this trajectory, not least because the country seems to have institutionally patronised the coal resource through the Ministry of Coal.

Between 2010 and 2014, China used to be South Africa's second most crucial coal export market, after which there was a precipitous decline. During 2015 and 2016, exports to China have decreased to less than 1% of total exports. The sudden decline could be partly attributed to China adopting new, less polluting technologies in its coal power plants such as HELE.

India is South Africa's leading export market and, as things stand, it appears that this will continue into the foreseeable future. Perhaps no other country has patronised coal as an energy resource as much as India has by having established the Ministry of Coal.

European countries used to import a significant amount of South African coal as a share of total exports. However, strict environmental laws have resulted in a substantial decline in the use of coal. Italy, the Netherlands, the UK, and Spain used to be the country's major export markets.While stricter environmental laws in some export markets present one risk factor, the other risk factor relates to the type of coal that South Africa exports. Most HELE coal power plants make use of higher grade coal. wn

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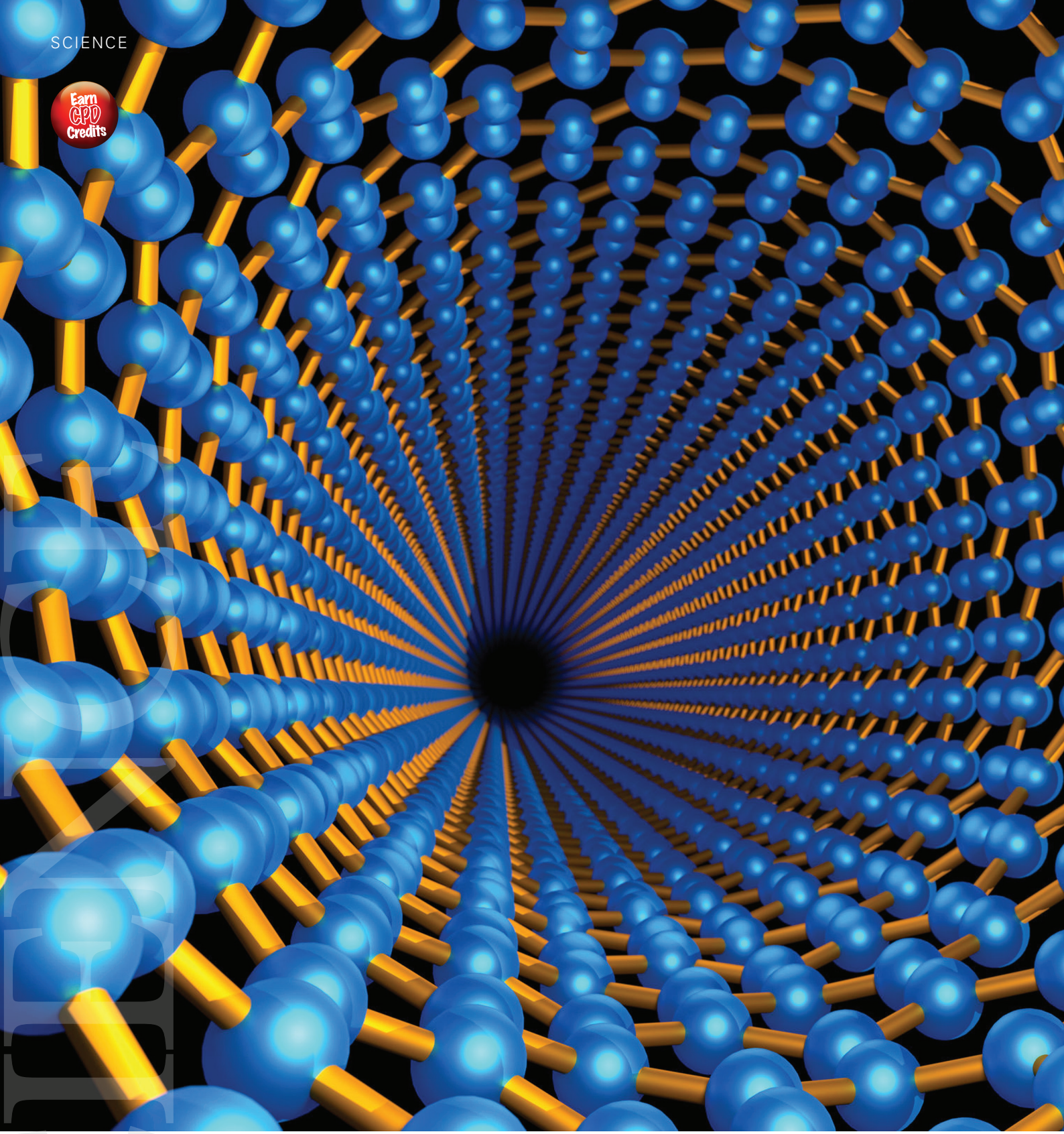
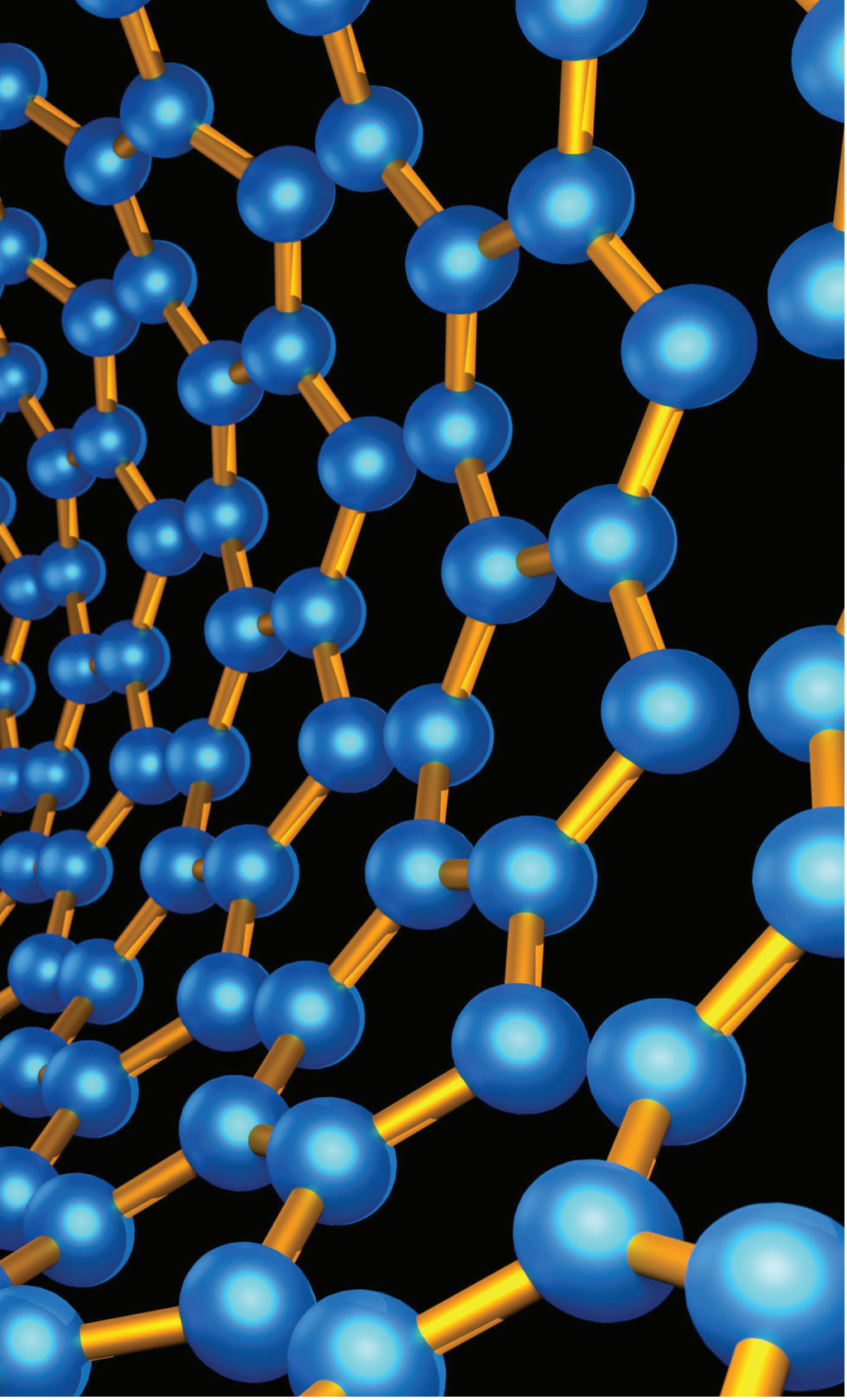


Carbon Nanotubes



It seldom happens that a new technology appears with as much promise for new innovative developments in science and engineering as carbon nanotubes.

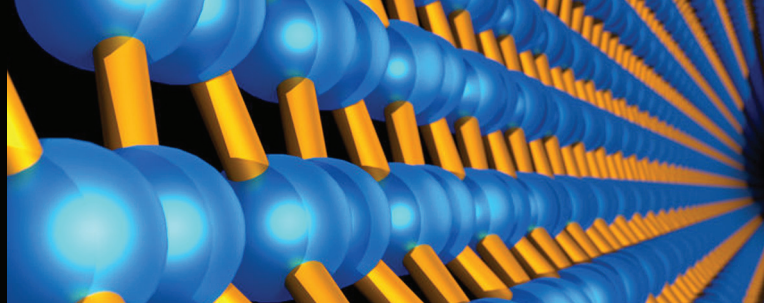
BY | DUDLEY BASSON

Carbon nanotubes (CNTs) are a tubular form of the quantum material graphene. In sheet form, graphene is a single layer of carbon atoms arranged in a hexagonal lattice, which has the highest tensile strength of any known material. This material is also an excellent conductor of heat and a better conductor of electric current than copper. It is almost entirely transparent, yet so dense that not even helium can pass through it. The single greatest obstruction to the widespread use of carbon nanotubes is cost – in particular, the cost of tiny diameter nanotubes.

Graphene was observed as early as 1962, but carbon nanotubes received unprecedented worldwide interest in 1991, when Japanese scientist Dr Sumio Iijima wrote his groundbreaking paper, fuelling intense research in nanotechnology. Dr Iijima has an astonishing professional record with several professorships and directorships and has been the recipient of a large number of prestigious academic honours and scientific awards.

Fullerenes are a class of carbon molecules of many shapes which include carbon nanotubes and spheres. Spherical fullerenes are known as buckminster fullerenes or buckyballs, named after Richard Buckminster Fuller (1895-1983), an architect renowned for his geodesic latticework domes.

Carbon Nanotubes



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The first fullerene to be discovered, the C_{60}, was manufactured in 1985 at Rice University but was identified some five years earlier by Sumio Iijima. The 60 carbon atoms of the C_{60} correspond to the vertices of a truncated icosahedron. The icosahedron has 20 triangular facets and 12 vertices. When the vertices are truncated, 12 pentagons are formed, and the triangles are reduced to hexagons. This is the familiar pattern of the polyhedral soccer ball with 12 black pentagons and 20 white hexagons. There are possibly more than 30 forms of fullerenes. Fullerenes C_{60}, C_{70}, C_{76}, C_{82} and C_{84} have been found to occur in nature and even in outer space. Fullerenes enclosing other material are known as endohedral fullerenes.

If CNTs can be placed in very specific locations, they can be aligned to form a wire. Rice University scientists have demonstrated teslaphoresis, a process using a Tesla coil to align CNTs into a filament.

The 2010 Nobel Prize in Physics was awarded jointly to Professors Andre Geim and Konstantin Novoselov, both of Manchester University: *"for groundbreaking experiments regarding the two-dimensional material graphene"*.

Professors Geim and Novoselov extracted the graphene from a piece of graphite such as is found in ordinary pencils. Using adhesive tape, they managed to obtain a flake of carbon with a thickness of just one atom. This at a time when many believed it was impossible for such thin crystalline materials to be stable.

With graphene, physicists can now study a new class of two-dimensional quantum materials with unique properties. Graphene makes experiments possible that give new insights to phenomena in quantum physics. A vast variety of practical applications now appear possible including the creation of new materials and the manufacture of innovative electronics. Graphene transistors are predicted to be substantially faster than today's silicon transistors and result in more efficient computers.

As it is practically transparent and an excellent electrical conductor, graphene is suitable for producing transparent touch screens, light panels, and possibly even solar cells.

When mixed into plastics, graphene can turn them into conductors of electricity while making them more heat resistant and mechanically robust. This resilience can be utilised in new super durable materials, which are also thin, elastic and lightweight. In the future, satellites, aircraft and cars could be manufactured using the new composite super-materials.

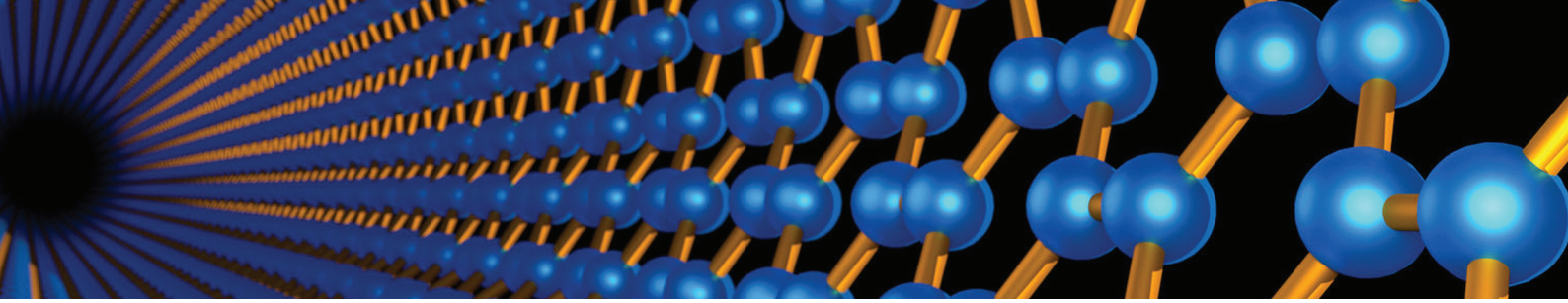
The 2008 Kavli prize in nanoscience was awarded to Prof Louis Brus and Dr Sumio Iijima: *"for their large impact on the development of the nanoscience field of the zero and one-dimensional nanostructures in physics, chemistry, and biology."*

Louis Brus created the interdisciplinary field of colloidal semiconductor nanocrystals, through original discovery, theoretical modelling, chemical synthesis of purified samples, and by studying the spectroscopy of individual nanocrystals. His research, leadership, and mentoring have played a leading role in opening world-wide interest in colloidal nanomaterials with controlled size-dependent properties. The results of his studies have led to a surge of activities by many researchers in the fields of synthesis and the application of these colloidal nanoparticles in many areas of chemistry, biology, and medicine.

Colloidal semiconductor nanocrystals, commonly called Quantum Dots (QD), have many properties such as the dependence of their fluorescence wavelength on the size and their long-time stability. This makes them suitable for fluorescence-based dynamic studies of molecular interactions and reactions in biological systems. Quantum dots are semiconductor particles only a few nanometres in size with properties differing from those of larger size and are a central theme in nanotechnology.

Researchers have described how they created the high-efficiency white LEDs in Optica, The Optical Society's Journal for High Impact Research. The new LEDs use commercially available blue LEDs combined with flexible lenses filled with a solution of nano-sized quantum dots. Light from the blue LED causes the quantum dots to emit green and red, which connects with the blue emission to create white light. An efficiency of 120 lumens per watt has been achieved, but this is expected to rise to 200, which could have significant implications for the lighting industry.

Sumio Iijima prepared a new type of finite carbon structure consisting of needle-like tubes using an arc-discharge evaporation method. He also did a careful electron microscopic analysis of the structure that revealed that each needle comprises coaxial tubes of graphitic sheets, ranging in number from 2 up to about 50. On each tube, the carbon atom hexagons are arranged helically about the needle



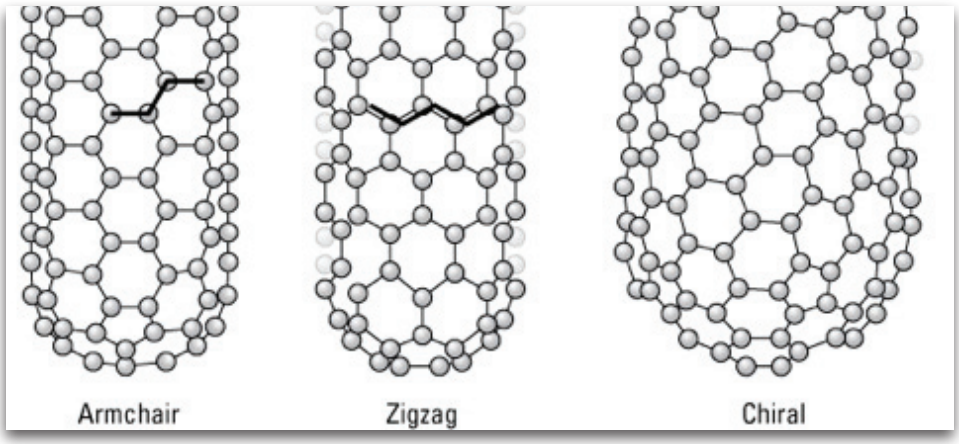
axis. The helical pitch varies from needle to needle and from tube to tube within a single needle. From this detailed structural analysis, he has pointed the way to many future applications of these nanotubes.

The nanotubes have interesting mechanical, electrical, and thermal properties. They are much stronger than steel at one-sixth of the weight. For these reasons, they are used in the reinforcement of mechanical strength in composite materials ranging from everyday items like clothes and sports gear to construction materials such as cement.

The electrical and thermal properties of nanotubes change with their diameter and are sensitive to the way the nanotube is formed. Depending on their atomic structure, they can have semiconducting or metallic properties.

For this reason, they have potential use as electronic components such as diodes and transistors, wires, transparent and conductive films, electrodes for super-capacitors, field emitters for displays, and sensor applications. The functionality of nanotubes can be expanded by filling them with active atoms and molecules for various future uses. Tubes filled with solid water can conduct electric current by transporting electrons in one direction and protons in the other. Filled nanotubes are reminiscent of a pancake shop where rolled up pancakes are offered for sale with a selection of fillings.

Colloidal semiconductor nanocrystals and carbon nanotubes will thus play a vital role in the future of various applications of nanoscience in the fields of energy, environment, electronics, chemistry, composite materials, and biomedicine.



NANOTUBE INDUSTRIALISATION

Despite the difficulties of manufacturing products too small to be seen, even with the use of an optical microscope, and the high prices associated with an early stage of development, there are at present well over 60 manufacturers supplying carbon nanotubes to a wide range of specifications.

Some manufacturers have an annual production over 100 tons of multi-walled nanotubes.

There are three primary configurations: Single-walled, Double-walled and Multi-walled, available in various lengths and diameters. In these configurations, there are three structures available: armchair, zigzag and chiral.

They differ in chiral angle and diameter. Armchair nanotubes share electrical properties similar to metals. The zigzag and chiral carbon nanotubes possess electrical properties identical to semiconductors.

A structural pattern emerges from the way the graphene sheet is wrapped which is represented by a pair of indices (n,m) which denote the number of unit vectors along the two directions in the tube.

Where:
m=0 indicates zigzag nanotubes.
n=m denotes armchair nanotubes
Other values mean chiral nanotubes.

Nanotubes cannot be made from graphene sheets and must be individually grown. The chiral nanotubes have a suggestion of left-hand and right-hand screw threads. An important factor is the tube diameter, which will be dictated by the end user. Nanotubes can also be supplied blended with polyamide as ready to use the material known as Nanotube Masterbatches.

There are several manufacturing processes in use.

Fullerenes were first observed after vaporising graphite with a short-pulse, high-powered laser. This was not a practical method for making large quantities.

The first method for producing CNTs and fullerenes in reasonable quantities was by applying an electric current across two carbonaceous electrodes in an inert gas atmosphere. This method is called plasma arcing. It involves the evaporation of one electrode as cations followed by deposition at the other electrode.

Carbon Nanotubes

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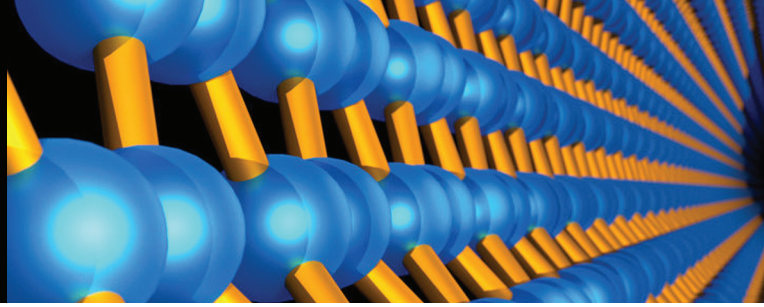
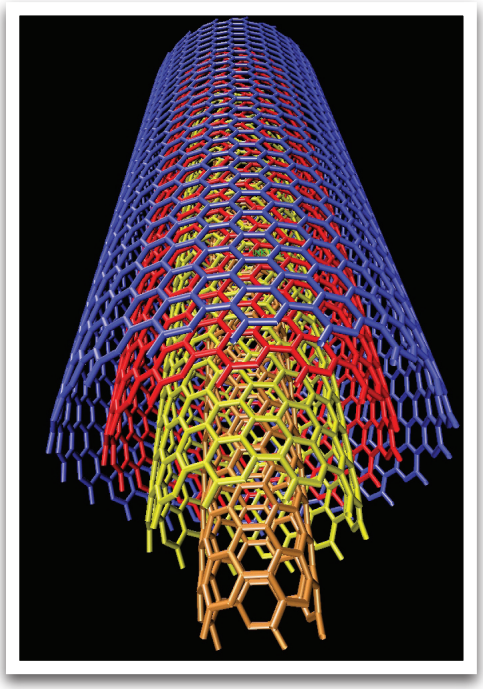




Multi-walled nanotube

Another method of nanotube synthesis involves plasma arcing in the presence of cobalt catalyst with a 3% or higher concentration.

The carbon arc discharge method, initially used for producing C_{60} fullerenes, is the most common and perhaps most natural way to produce CNTs, as it is rather simple.

However, it is a technique that creates a complex mixture of components and requires further purification to separate the CNTs from the soot and the residual catalytic metals present in the crude product.

Hipco is an arc method synthesis carried out under high pressure and was developed at Rice University to create high-quality Single-Walled Carbon Nanotubes (SWCNT) from the gas-phase reaction of the iron carbonyl with high-pressure carbon monoxide gas.

In 1996 CNTs were first synthesised using a dual-pulsed laser and achieved yields of over 70 wt% purity. Samples were prepared by laser vaporisation of graphite rods with a 50:50 catalyst mixture of Cobalt and Nickel at 1200°C in flowing argon, followed by heat treatment in a vacuum at 1000°C to remove the C_{60} and other fullerenes.

Undoubtedly the most common method of carbon nanotubes synthesis catalysed chemical vapour deposition of hydrocarbons over a metal catalyst is a classical method that has been used to produce various carbon materials such as carbon fibres and filaments for over twenty years. Large amounts of CNTs can be formed by catalytic chemical vapour deposition of acetylene over cobalt and iron catalysts supported on silica or zeolite.

Ball milling and subsequent annealing is a simple method for the production of CNTs. Although it is well established that mechanical attrition of this type can lead to fully nanoporous microstructures, it was not until a few years ago that CNTs of carbon and boron nitride were produced from these powders by thermal annealing.
Pricing of nanotube material is a complicated matter determined by the selection of a large number of options available. Industrial grade multi-walled nanotubes cost from $200 to $400 per kilogram. Blended masterbatches can be supplied off the shelf from $80 to $100 per kilogram.

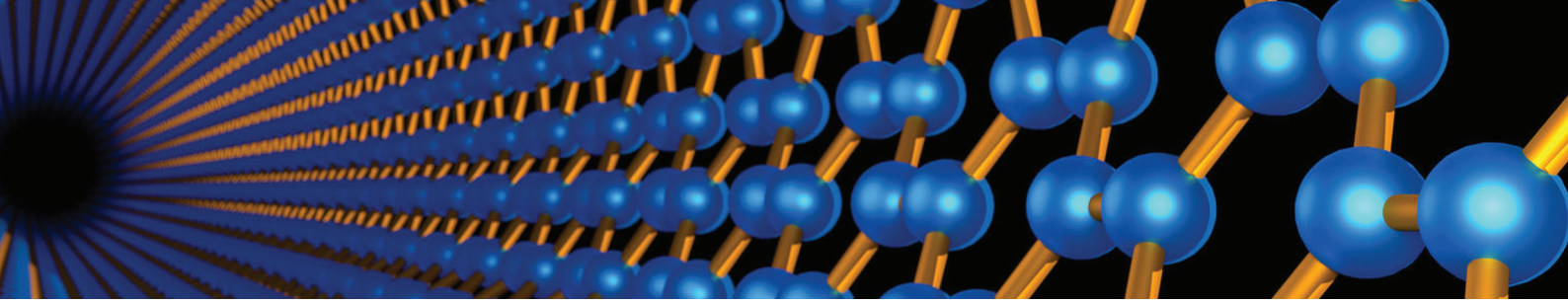
VANDERBILT RESEARCH

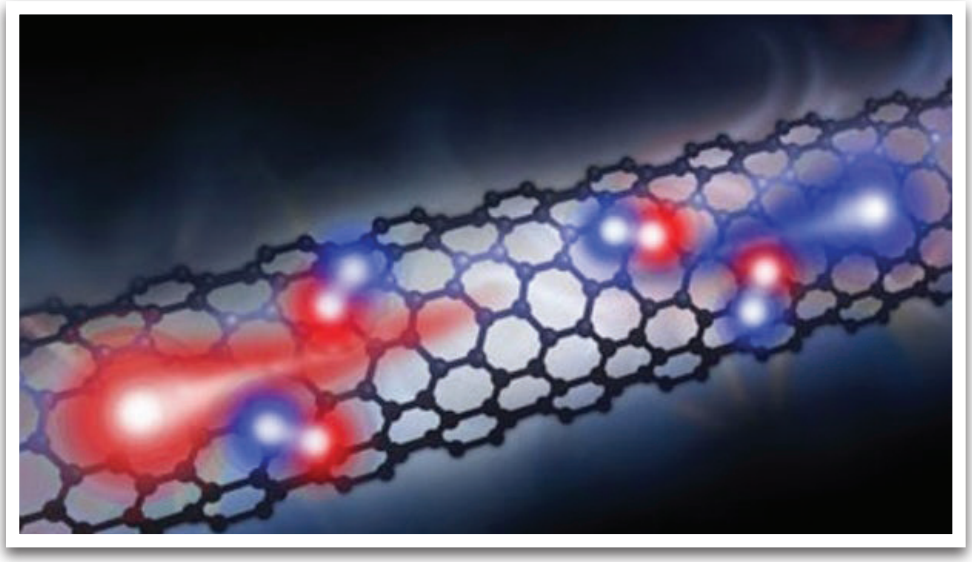
Vanderbilt University researchers, Assistant Professor of Mechanical Engineering Cary Pint, PhD student Anna Douglas, and their team are pursuing research to use atmospheric carbon dioxide to produce low-cost small diameter carbon nanotubes. This research uses electrochemistry to obtain carbon from atmospheric carbon dioxide which is then used to coat stainless steel surfaces. It is necessary to counter the Ostwald ripening process which causes the nanoparticles to grow to less useful larger sizes. The most useful sizes of tubes are less than 5 nm in diameter (a sheet of copier paper has a thickness of 100 000 nm). The tubes are too small to be optically imaged but can be imaged using an electron scanning microscope.

Small diameter carbon nanotubes (CNTs) require increased sophistication and control in synthesis processes but exhibit improved physical properties and more significant economic value over their larger diameter counterparts. Mechanisms were studied controlling the electrochemical synthesis of CNTs from the capture and conversion of ambient CO_2 in molten salts to achieve the smallest diameter CNTs. Iron catalyst layers were deposited at different thicknesses onto stainless steel to produce cathodes, and atomic layer deposition of Al_2O_3 is performed on Ni to provide a corrosion resistant anode. The findings indicate a correlation between the CNT diameter and iron metal layer thickness following electrochemical catalyst reduction at the cathode molten salt interface. Energy consumption analysis for the conversion of CO_2 into CNTs demonstrates energy input costs much lower than the value of CNTs and motivates the production of small diameter CNTs.

CARBON PHOTO CELLS

In September 2009, using a carbon nanotube instead of traditional silicon, researchers affiliated with the Kavli Institute at Cornell for Nanoscience, have created





Carbon nanotube photodiode

the essential elements of a solar cell that hopefully will lead to much more efficient ways of converting light to electricity.

A simple photodiode was formed from an individual nanotube.

Researchers led by Paul McEuen, the Goldwin Smith Professor of Physics, and Jiwoong Park, Assistant Professor of Chemistry and Chemical Biology, described how their device converts light to electricity in an extremely efficient process that multiplies the amount of electrical current that flows:

"In a carbon nanotube-based photodiode, electrons (blue) and holes (red) - the positively charged areas where electrons used to be before becoming excited - release their excess energy to efficiently create more electron-hole pairs when a light is shone on the device".

This process could prove necessary for the next generation of high-efficiency solar cells.

The researchers used a single-walled CNT to create their solar cell. With about the size of a DNA molecule, the nanotube was wired between two electrical contacts and close to two electrical gates, one negatively and one positively charged.

Their work was inspired, in part, by previous research in which scientists created a diode, using a single-walled nanotube. The Cornell team wanted to see what would happen if they built something similar, but this time shone a light on it.

By shining lasers of different colours onto different areas of the nanotube, they found that higher levels of photon energy had a multiplying effect on how much electrical current was produced.

Further study revealed that the narrow, cylindrical structure of the CNT caused the electrons to be neatly squeezed through one by one. The electrons moving through the nanotube became excited causing other electrons to flow.

CARBON NANOTUBE "ICE WIRE" CONDUCTORS

Carbon Nanotube "Ice Wires"could be the conductors of the future.

Researchers at MIT have found that in specific diameters of carbon nanotubes, a solid phase of water can exist at temperatures higher than 105 °C (378 K).

It has long been known that, given different amounts of space, the boiling and freezing points of water can change.

MIT researchers have taken this fact and tested it at the sub-microscopic level.

What they found is that the increased pressure of a carbon nanotube only a few water molecules wide can keep water frozen beyond boiling temperatures. This changes the long-held view of what people know as the traditional characteristics of phases of matter for water.

The familiar PT (pressure, temperature) diagram of water shows at which values the solid, liquid, gas and supercritical fluid phases occur, as well as where the triple and supercritical points arise.

Several other phases occur when extending this diagram beyond the range of engineering thermodynamics to the terapascal pressures of quantum physics - each conforming to a set of uniform properties.

The nanotube geometry can influence the phase transition of water. It is possible for a solid phase of water to exist in a single wall nanotube of 1,05 nm diameter up to a temperature of 138 °C.

Carbon Nanotubes

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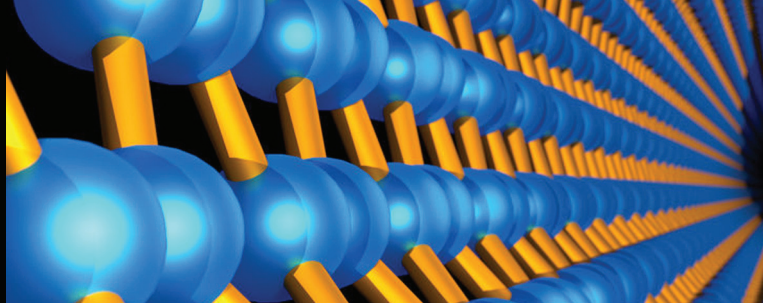
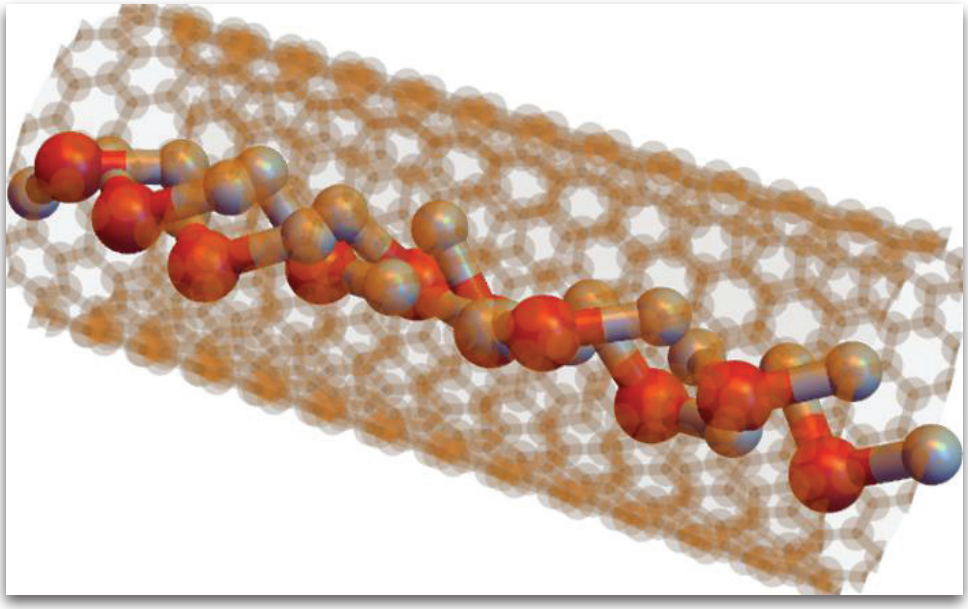




Carbon Nanotube "Ice Wire"

Some carbon nanotubes exhibit the property of ballistic conduction (negligible resistivity due to scattering). This means that electrons can travel freely along the length of the nanotube until they collide at the end of the tube. The solid water at high temperatures means that protons may be transported as well. The current carrying capacity of single-walled nanotubes (SWNTs) is estimated at a phenomenal 10^5 A/mm^2, but theoretically, this could be as high as 10^9 A/mm^2.

While copper is the dominant conductor of choice in the market today, and will likely stay that way for a long time to come, future generations might see devices and power transmission lines made of carbon nanotubes filled with solid water. The 'ice wires' could also be called 'sugar wires'. A sugar molecule contains twelve carbon atoms and eleven water molecules which can be easily separated using acid. Sugar has been found to be the optimal source of carbon for doping MgB_2 superconductors, especially for application in high magnetic fields. Current capacity has reached 100 A/mm^2 for Fe-sheathed sugar doped MgB_2 wire in an field of 10 T and cooled to 5 K.

Extreme pressure experiments have been done to produce metallic hydrogen.

In 1935 Eugene Wigner and Hillard Bell Huntington proposed that a pressure of 25 gigapascals could produce metallic hydrogen. It was thought that metallic hydrogen could only exist at the cores of giant planets such as Jupiter and Saturn due to the immense pressure required. Recent pressure estimates for producing metallic hydrogen have been put at 400 to 500 gigapascals.

On 5 Oct 2016 Harvard scientists Prof Isaac Silvers and Dr Ranga Dias succeeded in producing metallic hydrogen at a pressure of 495 gigapascals using diamond anvils. This is a pressure of about 5 million atmospheres. The anvils had to be meticulously polished to reduce the risk of shattering. The hydrogen at first turned black and then shiny reflective. It could not, however, be established if the metallic hydrogen was liquid or solid. The results have yet to be confirmed by further experimentation.

It is thought that metallic hydrogen might retain its properties after the extreme pressure is removed, as happens with diamonds after crystallising under intense pressure. This could well be a high-temperature superconductor.

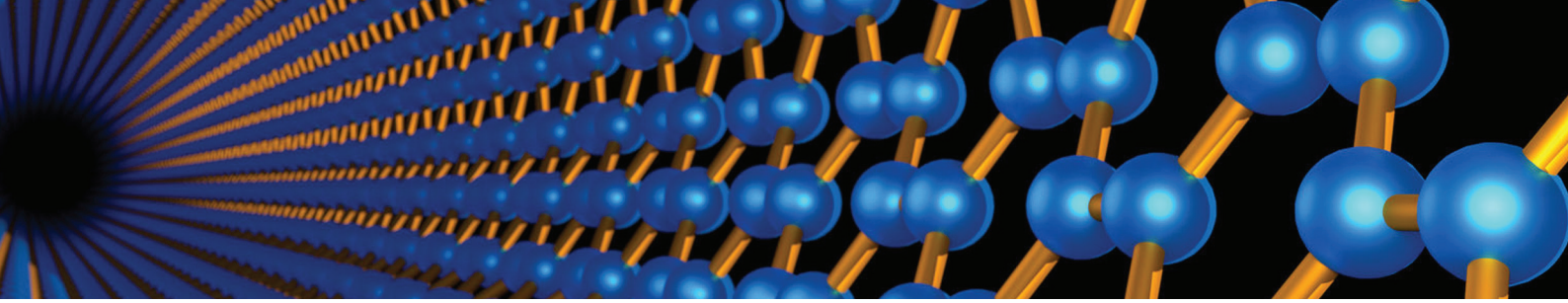
NANOTUBE WATER DESALINATION

Meni Wanunu, Associate Professor of Physics, and his Post-Doctoral Student Robert Henley at Northeastern University. USA are using carbon nanotubes as a filter to desalinate water. Their new paper shows the method works better than any other existing process.

Current desalination technology is energy intensive and expensive on a large scale so that the new technology could have significant implications for the future of water treatment and the full availability of potable water.

The carbon nanotube method developed the by researchers is successful because it easily separates individual water molecules that tend to cling together due to hydrogen bonds. Besides, because the nanotubes carry a negative charge, they also work to repel the negatively charged ions in salt.

This double action of separating clinging water molecules and repelling salt works together in the desalination process. This



process is active with salinities which exceed that of seawater. The nanotube used for this technique has a diameter of precisely 0,8 nm, a size that causes water molecules to pass single file through the nanotube.

NANOTUBE CLOTHING

Engineers at the University of Cincinnati are entering into a partnership with the Wright-Patterson Air Force Base to create clothing that can charge the wearer's cell phone. This would harvest ambient electromagnetic radiation from various sources.

UC Professor Vesselin Shanov co-directs UC's Nanoworld Laboratories with research partner and UC Professor Mark Schulz, to harness their expertise in electrical, chemical and mechanical engineering to create smart materials that can power electronics.

Shanov commented: *"The major challenge is translating these beautiful properties to take advantage of their strength, conductivity and heat resistance."*

Schulz remarked: *"Manufacturing is at the cusp of a carbon renaissance. Carbon nanotubes will replace copper wire in cars and planes to reduce weight and improve fuel efficiency. Carbon will filter our water and tell us more about our lives and bodies through new biometric sensors. In the past, metals dominated manufactured goods, but I think that carbon is going to replace metals in many applications."*

UC's Nanoworld Lab directs the collective work of 30 graduate and undergraduate students.

UC Researchers grow nanotubes on small silicon wafers under heat in a vacuum chamber through the chemical vapour deposition process.

UC's Nanoworld Lab set a world record in 2007 by growing a nanotube that stretched nearly 2 centimetres, the most extensive carbon nanotube array produced in a lab at the time. Since then much longer nanotubes have been created. UC researchers stretch the little fibrous square over an industrial spool in the lab. Suddenly, this tiny sheet of carbon becomes a spun thread that resembles a spider's silk that can be woven into textiles.

Shanov said: "It's exactly like a textile, we can assemble them like a machine thread and use them in applications ranging from sensors to track heavy metals in water or energy storage devices, including supercapacitors and batteries."

For the military, this could mean replacing heavy batteries that charge the growing number of electronics that make up a soldier's loadout: lights, night-vision and communications gear.

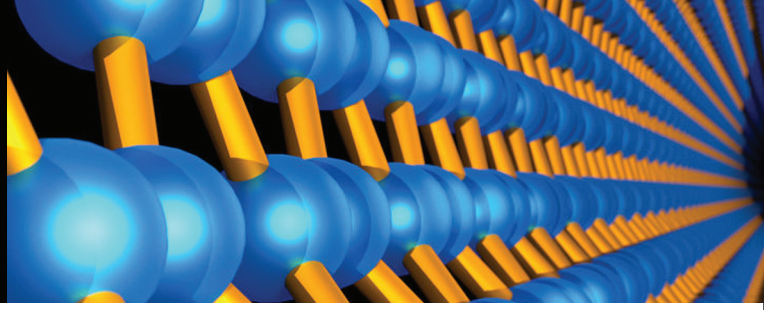
In a paper published on 8 August 2018, researchers at MIT described embedded high-speed optoelectronic semiconductor devices, including light-emitting diodes (LEDs) and diode photodetectors, within fibres that were then woven at Inman Mills, in South Carolina, into soft, washable fabrics and made into communication systems.

This marks the achievement of a long-sought goal of creating "smart" fabrics by incorporating semiconductor devices - the essential ingredient of modern electronics - which until now was the missing piece for making materials with sophisticated functionality.

DNA SEQUENCING

Faster sequencing of DNA holds enormous potential for biology and medicine, particularly for personalised diagnosis and customised treatment based on each's genomic makeup. At present, however, sequencing technology remains cumbersome and cost prohibitive for most clinical applications, though this may be changing, thanks to a range of innovative new techniques.

Carbon Nanotubes



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Stuart Lindsay, director of Arizona State University's Centre for Single Molecule Biophysics at the Biodesign Institute, demonstrated the potential of one such method in which a single-stranded ribbon of DNA is threaded through a carbon nanotube. These voltage spikes provided information about the passage of DNA bases as they pass through the tube - a process known as translocation.

Traditional methods for reading the genetic script, made up of four nucleotide bases, adenine, thymine, cytosine and guanine (A, T, C, & G), typically rely on shredding the DNA molecule into hundreds of thousands of pieces, reading these abbreviated sections and finally, reconstructing the full genetic sequence with the aid of massive computing power. A decade ago, the first human genome - a series of over 3 billion chemical base pairs - was successfully decoded, in a biological tour de force. The undertaking required around 11 years of painstaking effort at the cost of $1 billion. In addition to the laboriousness of existing techniques, accuracy is compromised, with errors accumulating in proportion to the number of fragments to be read. It must be mentioned that there is no single human genome – each living human has an individualised genome.

A new strategy involves the use of nanotubes — orifices of molecular diameter that connect two fluid reservoirs. A constant voltage can be applied between two electrodes located at either end of the nanotube, inducing an ionic current to flow through the length of the nanotube's enclosed channel. At this scale, the passage of even a single molecule generates a detectable change in the flow of ionic current through the tube. This current is then electronically amplified and measured. Only relatively recently have state of the art micro-manufacturing techniques enabled researchers to construct nanotubes at the scale of individual molecules, opening up many new possibilities for single-molecule manipulation and research.

In the current study, single-walled carbon nanotubes, 1 to 2 nm in diameter, were used for the conducting channels. When a current was induced through the nanotube, segments of single-stranded DNA (known as oligomers) made up of either 60 or 120 nucleotides, were drawn into the opening of the nanotube and translocated from the anode side of the nanotube to the output cathode side, due to the negative charge carried by the DNA molecule. The velocity of DNA translocation is dependent on both the nucleotide structure and molecular weight of the DNA sample.

Lindsay emphasises that DNA sequencing could be carried out thousands of times faster than through existing methods, at a fraction of the cost. Realizing the one-patient-one-genome goal of personalised medicine would provide essential diagnostic information and help individualised pioneer treatments for a wide range of diseases.

NANOTUBE ELECTROMAGNETS

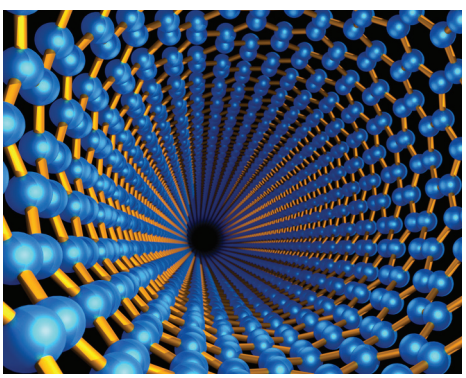
Generating high strength magnetic fields is complex and challenging in the extreme. The highest strength sustained magnetic field achieved using superconducting electromagnets stands at 45 T. Pulsed magnetic fields of up to 100 T have been made without self-destruction of the equipment. Short-pulsed fields of up to 1 kT can be achieved but result in the explosion of the electromagnet.

The exceptional current carrying capacity of nanotubes opens up exciting possibilities for super-magnets. The limits on the stable sustained magnetic fields are due to the magnetic forces on the conducting elements that tend to tear them apart. The limit to the mass of conducting material required to produce the field is set by the tensile strength needed to withstand the magnetic self-force on the conductors.
Copper has a tensile strength of 220 MPa and a density of 8 920 kg/m^3.

The highest measured tensile strength of CNTs gave 160 GPa and has a density of 1 300 kg/m^3, providing an increase of 5 000 to the strength to density ratio over that of copper. These figures suggest a phenominal field strength of 2 100 T. Considering only the tensile strength of the conductors; this would give a field strength of 840 T.

As a practical example let us take a 100-micron diameter wire of nanotube material carrying one million amps.

Using formula $B = \mu_0 I / 2 \pi b$ the field strength at 100 microns from the wire centre would be 2 000 T. Carrying a current of one million amps in a wire as thick as a piece of paper may seem absurdly far removed from reality, but such are the prospects of nanoscience. wn



SAIEE webinar announcement:

Lightning over Johannesburg

DATE: 2 OCTOBER 2018 | 18H00 - 19H00

Dr Hugh Hunt

Dr Carina Schumann

SAIEE

T +27 11 487 3003 | **E** reception@saiee.org.za

Registration: https://attendee.gotowebinar.com/register/6208100329257660419

As a follow-up to the corresponding August **watt**now article, the SAIEE is hosting a webinar titled "Lightning over Johannesburg, and some of the first high-speed video observations."

The presentation will discuss some of the previous studies of lightning in South Africa, along with more recent work being done at the University of the Witwatersrand at the School of Electrical and Information Engineering. How it fits into the current global research will also be presented.

PRESENTERS

Dr Schumann has been studying the physics of lightning in Brazil, the USA and Austria for over ten years. She graduated from the Federal University of Itajubá with a degree in Physics. She completed her PhD and MSc in Atmospheric Electricity at the Brazilian National Institute for Space Research and is currently a postdoctoral fellow at the University of the Witwatersrand. She is published in over 30 peer-reviewed scientific articles.

Dr Hunt is a lecturer in the School of Electrical and Information Engineering. He completed his BSc in 2009, MSc 2012 and PhD in 2018 (all from the University of the Witwatersrand), looking at the use of lightning location system data in forensic investigations. know.

Down Memory Lane

My 60 Years of Engineering

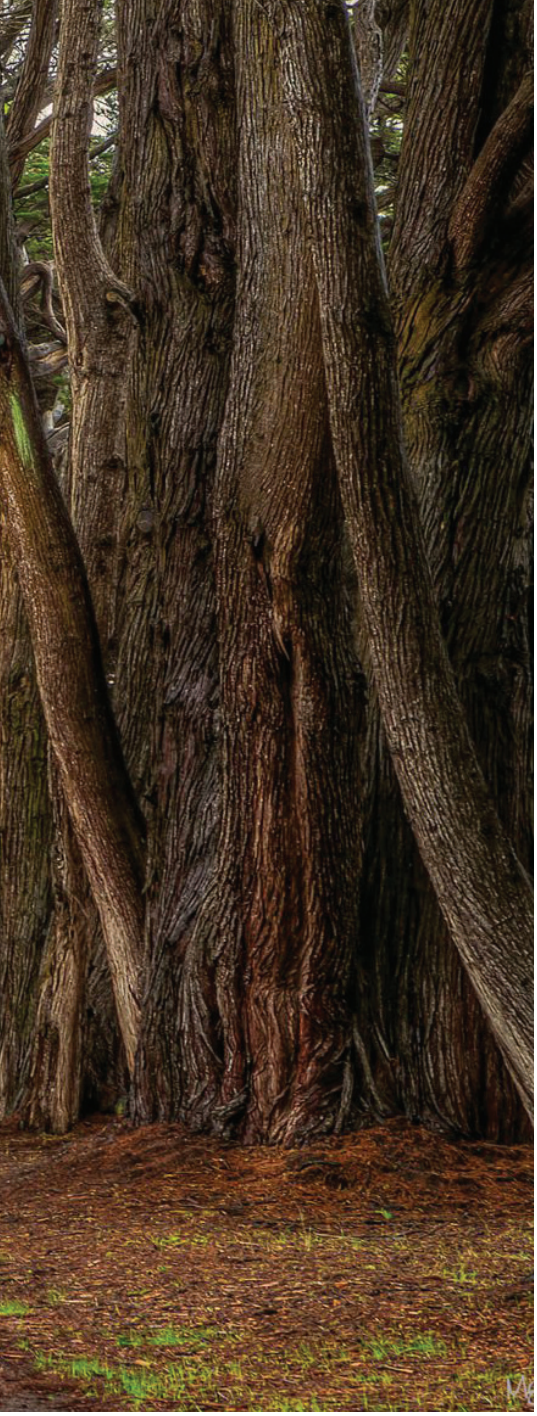
BY | WOLF WEIDEMANN | PR ENG | MSAIEE | MCESA | BSC | BING | SMIEE

Inspired by Bruno Penzhorn's "Memories" (May 2018) and the invitation by Managing Editor, Minx Avrabos, I would like to also look back through my rear window, which although smaller is always cleaner than the windshield of the future.

WHY I BECAME AN ENGINEER

I was born to immigrant teacher parents from Germany and raised in Windhoek, then Southwest Africa (SWA). It was my good fortune to have a godfather who was a farmer in the Okahandja district, but who also built radios with parts he had brought along from Germany. After WWII he gave me essential guidance and enough hardware to construct a one-valve shortwave positive feedback audion[1]. My mother was not too impressed with the battery acid spills on my bedroom floor but allowed the erection of a large L-aerial. With headphones, I was glued to stations far and near and was – in a word – hooked! Mathematics and Science were favourite subjects in high school, although Latin helped me with my English. A neighbour's son, Hartmut Beckurts, had graduated in engineering from Stellenbosch and instructed me very explicitly that this university had the engineering faculty best for any "Southwester". He even told me which dormitory I should apply. Who was I to argue? With a study loan from the SWA Administration, I set out on the three-day train journey into the great unknown.

1. The Audion was an electronic detecting or amplifying vacuum tube invented by American electrical engineer Lee de Forest in 1906. It was the first triode, consisting of an evacuated glass tube containing three electrodes: a heated filament, a grid, and a plate.



THE BEGINNING YEARS: COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

It is perhaps interesting to know why I, with a fresh five year BSc, BIng degree in electrotechnical engineering (light current) of Stellenbosch behind my name, could start as "*The Engineer* of the Cyclotron[2] group" at the Council for Scientific and Industrial Research's (CSIR) National Physics Laboratory on Wednesday, 2 January 1957. No pupil, no candidate or -in-training engineer! But then, my favourite professors such as Göldner (Mathematics), Heydorn (Electrical) and Straszacker (Mechanical), were not forced to concentrate on "research" for their own promotion. Unlike today, their prime goal was to produce the best engineers they knew how, covering a wide spectrum, with as much student contact as possible. (Actually, my supposed main teacher in "light current", who had set up a very modern laboratory, complete with Radar installation and analogue computer, was himself a brilliant engineer but a mediocre lecturer.)

At the CSIR, Dr SJ (Stefaan) du Toit, head of the Nuclear Physics Division, was my immediate superior. This physicist, fortunately, was aware of Albert Einstein's dictum *"Scientists investigate that which already is. Engineers create that which has never been."*

His trust, confidence in my abilities and helpful guidance encouraged and brought out the best in me. This early example of McGregor's Theory Y management also became my style throughout my later career.

The previous "cyclotron engineer" had designed and built a beautiful and impressive machine, but alas, the internal beam of the cyclotron vanished somehow before reaching the full 16 MeV[3] design acceleration which thus could not be achieved, nor could the beam be deflected to the next-door shielded experimental hall. He was not interested in the lengthy finicky tuning required to reach full energy and deflection but instead joined the S.A. Philips Laboratories in July 1956.

I now had to head up the group of Dutch *"Middelbare/Hogere Technische School"* technologists who had built the nuclear particle accelerator. (The Nuclear Physics building with its impressive deep down machine hall cellar was the first on the present CSIR site.) I was only 21 years of age, but thanks to the various 6-week summer vacation "practicals" during my studies, I had developed a sound appreciation of the full and necessary engineering complement of an engineer, technician and artisan. I respected their respective contributions and knew how to work with them. As a result (and with lots of luck!) I managed to form the group, into a team which was willing to work under my guidance. The most experienced technologist, however, did not take too kindly to this young engineer now in charge, although of course, he enjoyed a much higher salary himself. But after some time it was again proven that even if some men might not like each other, they can still work together highly productively if mutual respect is engendered.

With regards to the problems with the cyclotron, I first put all hands on tidying up the hastily executed experimental terminations of the many multicore signal cables connecting the control room at ground floor, to the repeater panel in the cyclotron hall - 9 metres down and

2. Cyclotron: A nuclear particle accelerator.
3. MeV: Million (or Mega) electron Volt

Down Memory Lane

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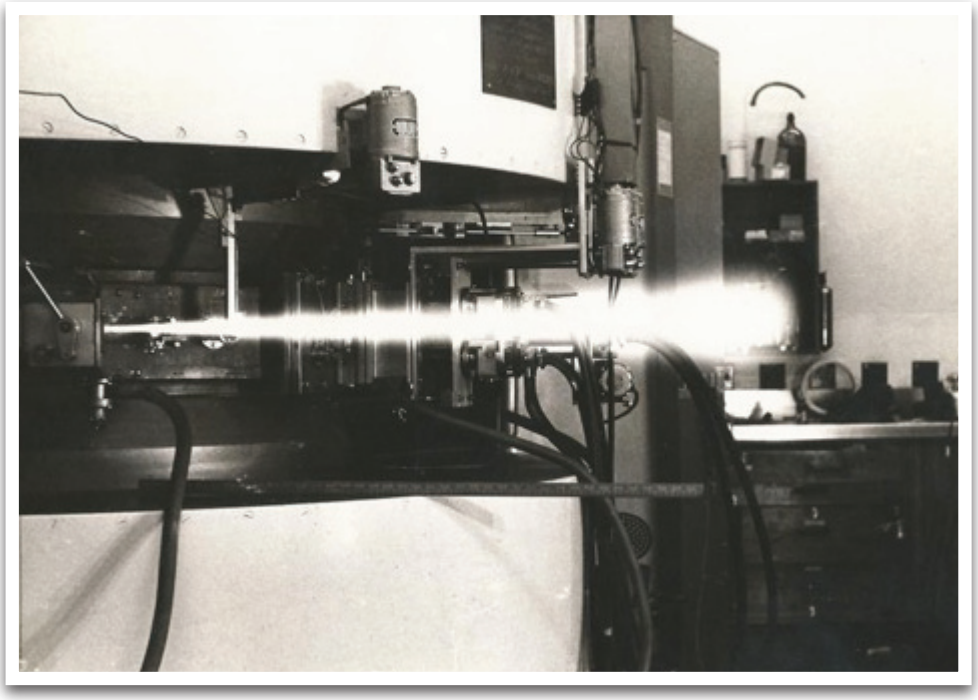
40 metres away. These had caused numerous interruption faults, and the documentation varied from non-existent to poor. Fortunately, one of "my" technicians had extensive experience of cable installations to industrial standards, and under his guidance, a vast improvement in reliability and traceability was achieved with little delay to the overall programme. Even this had to be revised in my first progress report, which affirmed that previous reports had grossly overstated the actual advance. (This tendency to portray "just around the corner" developments already achieved lead to a cumulative reporting gap between the actual and the wishful!).

As good fortune had ordained, my BEng thesis had been about the puzzling experimental results with the "Epstein square[4]", used to measure the magnetic and ohmic losses of transformer laminations.

For many years this final-year experiment had delivered satisfactory results, possibly because it was carried out without supervision? However, when the new Danish lecturer, Engineer Rolf Braae, arrived at Stellenbosch, he started assisting and supervising such experiments very conscientiously. Now, suddenly, the good "Epstein square" results of generations of final year electrical students could not be repeated! Braae promptly persuaded me to apply the Theory of Measurements (Danish "Maaleteori", which now was a final-year subject) to this unexpected discovery. The thesis, involving running electric motors and generators quite daringly at multiples of their design speeds (to achieve higher frequencies), proved beyond any doubt that all previous generations had simply "cooked up" their good experimental results, as these could not possibly have been obtained



First external unfocused 16 MeV deuteron beam emerging from the cyclotron.

with the usual set-up. Thus I now could bring good knowledge of measurements and magnetism to bear on the mystery of the disappearing ion beam. This eventually could be traced to the fact that other than the solid poles of the 80-tonne magnet which had been forged from ISCOR's (Iron and Steel Corporation) unique pure iron billets, the 50 mm thick magnetic pole plates forming the top and bottom of the vacuum chamber had been manufactured from the rolled plate of the same iron. This rolling had led to preferential directional magnetic susceptibility, thus upsetting the azimuthal field uniformity despite the fantastic ± 0,03 mm machining tolerance which VECOR (VanderBijl Engineering Corporation) had achieved on all magnetic contact surfaces.

Fortunately, sufficient material of the original iron was still available to undertake the problematic manufacture of cutting horizontally through a ±1250 mm diameter forged billet, from which two plates, each one 0,4 tonnes and now of similar magnetic properties, could then be machined with high precision. (Some of VECOR's large machine tools were still calibrated in the old pre-1932 American Standards Association of 1 inch being 25,400051 mm. We needed to compensate for the cyclotron's large components because it required a very close finish tolerance.)

With these new vacuum chamber lids and some additional "Thomas" shimming, it was possible to achieve the full energy and radius required for beam extraction. The beam was then directed to the adjacent experimental hall with the first South African quadrupole focusing system, manufactured in the excellent CSIR precision instrument workshop, again from left-overs of the original iron, following my design. The international publication of an

4. An Epstein frame or Epstein square is a standardised measurement device for measuring the magnetic properties of soft magnetic materials, especially used for testing of electrical steels.

"engineer's recipe" for the straightforward design of such quadrupoles received broad appreciation and recognition. My other contributions were mainly in the areas of electronics: measurements, instrumentation, and the finer and more stable control of the 1,7 Tesla magnetic field, also of the 13,25 MHz frequency of the 9 kW oscillator. Doing the latter with oscilloscopes then capable of maximum 5 MHz was quite a challenge.

ATOMIC ENERGY BOARD

After three years the cyclotron could now be handed over to the physicists for their experimentation, and the newly established Atomic Energy Board (AEB) recruited me. My wife of 1½ years, Marie, and I were sent to the USA where, within two years, I obtained a "Science Master in EE" and the pre-doctorate "Electrical Engineer" at MIT (Massachusetts Institute of Technology).

The pressure of time to join the South African contingent allowed only a year as Affiliate of the International Institute of Nuclear Science and Engineering at the Argonne National Laboratory near Chicago. This, however, was enough to become proficient in the applications and uses of the new-fangled transistor – especially for digital circuits; to publish a paper accepted by an international nuclear congress; and to admire a sample of the first integrated circuit (four flip-flops on a chip), costing hundreds of dollars. The mini-computer had yet to make an appearance on a scene dominated by IBM's million-dollar machines.

The progress of the AEB's Electronics and Instrumentation Division at Pelindaba can perhaps be illustrated by comparison with its start from a little subsection of the Physics Division, consisting of me and two junior engineers (also trained post their South African MEng in USA nuclear laboratories) and four electronic technicians. After 18 years it had developed into a fully-fledged separate Division, with me now Director, consisting of over 100 engineers, technicians and process assistants, with an electronic design group, a drawing office, a well-stocked component store, printed-circuit production, a mechanical workshop, an electronic instruments maintenance group, an industrial instrumentation maintenance group, and a financial controller. It was responsible for all installed instrumentation on site, including that of the SAFARI (South African First Atomic Reactor Installation) nuclear reactor, and for full support of the other divisions as far as their measurement and control requirements were concerned, including the development of any new experimental instrumentation which they required.

The Division's primary needs for own development and calibration instruments, led to the establishment of Hewlett Packard South Africa, while the massive consumption of components caused the upgrading of some "hobby" shops to fully-fledged suppliers of professional electronic components. During the production of all specialised instrumentation for the UCOR (Uranium Enrichment Corporation), Valindaba's uranium enrichment process (an American transistor manufacturer) even developed and branded a special "AEB-type". The growth of this division and the escalating responsibilities meant that my career now had to turn increasingly to management, explicitly engineering management. In this I was guided and supported by Dr Raimund Loubser, later Deputy General Manager of UCOR. (His brother Kobus was General Manager of SA Railways & Harbours, Motor Transport and Airways, all functional at the time.)

It is unquestionable that the pioneering activities of the AEB's Instrumentation Division – made freely available for duplication elsewhere – and its demands for outside support caused an upswing of the country's electronics capabilities and capacities. It must also be mentioned that the Division imported the first two mini-computers in 1967 and developed their use for the control of experiments and its production machinery. These computers, at the cost of a medium house, had a 4 kB magnetic core memory. Programming was in machine language and later Basic, and communication with them was by teletype! After my 18 years, the increasing "other activities" of the AEB and UCOR were starving the usual original research and development programmes, and it was time to move elsewhere.

THE PRIVATE SECTOR

Although Heini Blohm, then Chairman of Volkswagen South Africa, always maintained that he could and would never consider employing anybody who had been in Government/Public Service for more than five years, my transition to the Private Sector went relatively smoothly, perhaps because of the support of John Maree, CA, then the Crown Prince of Barlow Rand. He placed me at the University of Pretoria, to build a technological transfer bridge from their electronic ivory tower to the "smokestack" of Fuchs Electronics. The learning curve was steep indeed, but I received wonderful support and kind guidance from Eddie van Niekerk, the CFO of Fuchs. The initial misgivings of

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the competent Fuchs production engineers under the leadership of Bob Meerholz also had to be overcome. (Their level of expertise may be gauged from the fact that Bob Meerholz fitted the first South African airborne radar into Prime Minister Smuts' Avro York aircraft.)

Basic knowledge of business finances was taught to us of the Fuchs Executive by nobody less than John Maree himself, chairman of Fuchs Electronics after Barlow Rand had bought it upon the death of Charles Fuchs. On the university side "Barlow Lab" with its prototype production capability grew by leaps and bounds and had great success with the development of highly sophisticated electronic munitions needed in the Angola bush war. These were first manufactured by Fuchs and later by an Armament Board's contract factory. But success also led to jealousy by the Theory X management of the faculty's Department Head, who insisted on dividing the honours before a project could start. This clashed with my Theory Y approach and led to a break.

I decided that by now I had experienced and made almost all the possible mistakes and that it was time to become a Consulting Engineer. I joined GH Marais & Partners Inc. in 1981 and was soon appointed Director of Electronics and Instrumentation upon the emigration of some senior Associates to the Eden of the Western Cape. Again there was a steep learning curve to be conquered, but the support and example of Chairman Guillaume Marais and MD Ferdie Geyer smoothed the way somewhat. (Guill's attention at the time, unfortunately, had to focus mainly on the vast and pace-setting Electrification of Greater Soweto, which was nearing its end after the start in 1978. Today the cost would be over R 3 billion.) The Electronics department again proliferated and at some stage, its average period of consulting experience was only about six months! However, we did not drop a single project and produced some significant applications of the now ubiquitous mini-computers. Our expertise in telemetry and control was almost legendary and in high demand by the Department of Water Affairs. (Telemetry was ambiguous before the country-wide Cell networks were installed.)

To my surprise I found that the concept of 'middle management' was not common in consulting engineers' practices, nor was the partitioning of projects and smooth, natural delegation. One of the most significant challenges here is to ensure the quality of individual professional service to the clients, while yet assuring overall cohesion as a business. The usual pyramid (military) hierarchical structure, while excellent for control, cannot function as a system with a common goal, which an organisation should be. Instead of dependence, there should be interdependence, with communication and group work being encouraged. I found that my senior colleagues in the other departments worked alongside their staff, thus adding their expertise – instead of looking over their shoulders – in which case they would have multiplied it.

Alas, the result of the infamous 1985 'Rubicon Speech' was a deep economic depression with the general concomitant decline in demand for infrastructure development. To survive, GH Marais had to halve its 500 plus staff almost overnight. This was perhaps the most depressing and sad period ever of my career: to have to face good engineers and technicians and tell them that you no longer could afford their excellent services and friendship! Well, we did survive, and some prestigious projects gained the SAACE Award for Excellence.

Then the political scene darkened again and towards 1994 "right-sizing" yet still was unavoidable. I decided that I would not face another heart-ache of dismissing staff and chose to resign and not to join the subsequent merging (sub-merging?) of GH Marais with a sizeable civil consultancy.

"ON MY OWN"

What followed was an interesting but trying period: looking for gainful employment. Consulting Engineering was out. Applications for numerous positions in which I definitely could have made considerable contributions were turned down, unexpectedly! Support from individuals whom I had considered to be good friends was not forthcoming – I was avoided as if unemployment was a catching disease. But suddenly, others – at the time mere acquaintances – came forward with various proposed initiatives. One led to part-time lecturing at a new independent university. Another had the deep and lasting effect which led to my present involvement with the education and training of Consulting Engineers and other Built-Environment Professionals. Hugo Meyer was President of the South African Association of Consulting Engineers at the time and introduced me to its Continuing Education Committee. After many weeks of project definition the concept of the "Handling Projects" course was accepted and the rest, as the saying goes, is history, indeed a history of 22 years. To this course of how a Consulting Engineer makes his money later was added the "Finances" course, all about how he should collect and

manage this money. (My daughter Luise, a lawyer, still helps me with any legal aspects addressed in my courses, for instance, the ECT, RICA and MORA Acts.)

To summarise: My 60 years of Engineering can be partitioned neatly into three almost equal periods: Statutory Government (CSIR and Atomic Energy Board); Private Sector (Fuchs Electronics and GH Marais & Partners) and Independence (Weidemann Consulting). During this last stage, I have sadly witnessed the decline of the Consulting Engineering Industry, due to the corrosive effects of Discounting, Tendering and Political Interference. The fact that CESA's 550 member firms with 24 300 people are generating over R25 million in fees per annum means that this is still a significant organisation. However, the reality that the total debts outstanding for more than three months amount to R6,3 million (that is more than a quarter of a million Rand per person active in the consulting industry), to my mind, implies large-scale financial illiteracy and less than adequate management skills.

INVOLVEMENT IN PROFESSIONAL SOCIETIES

After returning from the USA, Dr Frank van Duuren – a consulting engineer also lecturing at the University of Pretoria – almost immediately cornered me to join the Engineers' Association of South Africa, founded just after WWII by Wits graduates. The mission was to unite professional engineers regardless of their speciality. I was National Chairman for the three years 1976 – 1978 and Honorary Membership was bestowed in 1984. I also served on the Council of the successor South African Society for Professional Engineers (SPE). The unification efforts were in vain – we still don't pull together on the same rope! However, becoming involved with such societies taught me to take excellent Minutes and later to become a competent Chairman.

I started and edited quite a few Newsletters, for example, "The Engineer", (the magazine of EASA, later SPE) from 1980 to 1990. This again sharpened my ability to put out the GH Marais Newsletter, then also that of Bohlweki and Kentron. I even compiled the Annual Report to Parliament of SACPE/ECSA for many years. Together with Frank van Duuren (who designed ECSA's emblem), I served on the SA Council for Professional Engineers/ECSA for 20 years, the same duration as I participated in various committees of SAACE (now CESA). I was an Accredited Peer Reviewer and a trainer in Targeted Procurement. This interaction with other engineering professionals was a natural highlight of my days. (It goes almost without saying that I am apprehensive about today's strange happenings at ECSA where strict peer review and registration seem to have come to a stand-still.)

In 1981 I got involved with SAFUES (the South African Federation of Engineering Students). In those years they arranged countrywide pedal-car races, with big organisations such as ESCOM, SAR&H, ISCOR, SASOL etc. also sponsoring teams and even designing and building their cars. I associated myself with "Team Velle" of Pretoria University, as the Pauw brothers – all Tukkie engineering students – had pioneered the revolutionary seating position, later universally accepted, and had built several winning cars. Now my oldest son Hermann started his mechanical engineering studies and full use was made of the WWW (Wolf Weidemann Workshop). He, and later QS-student brother Walter, became heavily involved in the Pedal-Car sport. So dad started detail designs to fit Hermann's overall layout dimensions and then built pedal cars, also attending the various races. The first-built aluminium car was very light but too soft. The later three were made of aircraft grade chrome-molybdenum steel, each improvement helping Team Velle to win the national championship for very many years. (The cost of a good car could easily escalate to about R10 000, which at the time was a great deal of money!) I would claim that the mechanical engineering and metallurgy background gained during my "light current electrical" studies were the deciding factor in building cars that had good road-holding, were light and yet did not break down. The latest model, Lamda, constructed pre-1990, was sold to the "Oumanne" team of Stellenbosch in 2006, who since then have won each yearly US race in their category.

CONTRIBUTION TO THE ENGINEERING PROFESSION

The two courses which I have been presenting under the auspices of SAICI and CESA have helped me a great deal to counter the effects of inflation in my later years. (Do you remember that up to 1980 one could buy a US dollar for 74 South African cents?!) However, I would also like to think that with my 300 courses and the attending 2 500 participants I not only moved about 2 tonnes of manuals but also ploughed back some of my experience into the engineering profession and that this was and hopefully remains to be of value.

I am thankful for the ability to have done so, under the guiding motto *"Rast ich, so rost ich": "If I rest, I'll rust".* wn

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

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

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

Send your burning questions to minx@saiee.org.za - subject 'WATT?'.

Q&A

QUESTION ONE

What information is required to ensure the correct Variable Speed Drive (VSD) is supplied for your application?

ANSWER ONE

VSD technology is playing an increasingly important role across a broad range of industries, and it is essential to understand what information is required to enable a supplier to provide the most appropriate VSD solution for a particular application.

There are several practical considerations, and the following information should be provided, wherever possible.

- What supply voltage does the application require?
  Is it a single phase or three phase? Is it 220V/380V/525V or 690V?
- What are the motor nameplate details?
- This should include the motor kW rating, the nameplate speed, the full load current of the motor and the motor voltage?
- What are the application load requirements? This should include information on the absorbed power (kW) required for this application as well as the required torque. It is also important to know whether this is a Normal Duty (ND) or Heavy Duty (HD) application. For example, will the motor and VSD be driving a pump, a fan or a conveyor and will variable or constant torque be required? In addition to this, it is necessary to know whether it will be a single motor or if the installation will require multiple motors connected to one VSD.
- What motor cable size and length are required for the application? Information about the VSD installation is required; i.e. is this an indoor or outdoor installation, and what level of Ingress Protection (IP rating) is needed? It is also important to advise if a particular enclosure is required for this application.
- What type of protection is used upstream to protect the VSD? Does this include fuses, circuit breakers and/or surge arrestors?
- What Stop and Start method is being used?
- Is it a two (2) or three (3) wire control?
- Is this an analogue or digital speed reference type?
- What type of communication protocol is being used?
- Is this Profibus, Ethernet, ProfNet, Device Net or other?

QUESTION TWO

Is it necessary to maintain a VSD?

ANSWER TWO

A regular preventive maintenance programme throughout the VSD lifecycle is an absolute requirement to ensure maximum availability and minimum unplanned repair costs.

WATT?

Information provided by Zest WEG Group

Without preventive maintenance, the probability of VSD failure increases drastically. The most common failures are due to component ageing or deterioration often related to operational conditions such as varying ambient temperatures and high humidity.

Scheduled preventative maintenance tasks should, at least, include:

- Visual inspection of the VSD enclosure or panel - this should include the examination of door seals to ensure that IP rating is maintained.
- The cleaning and/or replacement of all filters frequently, depending on the environmental conditions.
- Removal of excessive dust and dirt - this can be done by using a vacuum cleaner. Dust on an electronic device can cause malfunction or even failure, and when it absorbs moisture, it aggravates the problem.
- Inspect connections.
- Inspect the ribbon and fibre optic cables.
- Inspect the functionality of the fan and cooling system. It is advisable to change fans after 50 000 running hours.
- Inspect of the fault logger.
- Inspection and storage of the parameters.
- Functional testing of the VSD under normal conditions.

It should be noted that where maintenance is not being carried out by a competent, trained technician, it is not recommended to strip the entire VSD to inspect or clean the unit. This could potentially result in VSD failure and unscheduled downtime to the equipment.

QUESTION THREE

Can a VSD be stored for extended periods?

ANSWER THREE

A VSD can be stored for extended periods if it is stored under the correct conditions. It should be kept in a clean, dry environment free from dust and moisture. Minimum handling of the VSD is required as potential damage could occur by dropping or bumping the unit.

The capacitors in the VSD are the only components that need special care. If a VSD is stored without an electrical supply connected to the unit for more than a year, reforming of the capacitors will be required to avoid damage to the unit.

The electrolytic capacitors used in the inverter have an aluminium oxide layer deposited on the anode (positive pole), created by an electrochemical treatment called anodic oxidation. This oxide layer functions as a dielectric in the capacitor. When the capacitor remains out of use, this oxide layer tends to deteriorate, reducing its thickness. When the capacitor receives the voltage, the oxide layer starts a regeneration process due to the chemical reaction between the electrolyte and the aluminium on the anode foil. The regeneration process is called reforming.

If the reforming is not performed, depending on the level of the deterioration, the capacitor might be damaged after a short time in operation.

The process of reforming to be followed is : The unit needs to be powered up at least once a year for one (1) hour. For 220V to 380V units a supply voltage of 220V needs to be connected to the VSD without a motor on the output. For 500V to 690V units a supply voltage of 300V needs to be connected to the VSD without a motor on the output.

This procedure will ensure that the capacitors are reformed, and the VSD would now be ready for use or extended storage for one year. wn

September

Heritage Month

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

1 SEPTEMBER

1651 According to the book, the fictional character Robinson Crusoe embarked on his first sea voyage, from Hull to London. Daniel Defoe's story was based on the real-life adventures of Alexander Selkirk.

2 SEPTEMBER

1987 In 1987, Philips introduced the CD-video.

3 SEPTEMBER

2000 NASA data showed that the hole in the Ozone layer, over the Antarctic, was at just under 28.5 million square kilometres, the biggest it had ever been to date.

4 SEPTEMBER

aka Bright Idea Day

1882 The first newspaper plant to make use of the newly available electrical power provided by the Edison Illuminating Company was the New York Times.

5 SEPTEMBER

1862 English meteorologist James Glaisher and his pilot Henry Tracey Coxwell achieved a balloon ascent to a height of 7 miles (11.265 km). Although this was the greatest height then achieved by passengers in a balloon, its precise altitude is unknown because Glaisher lost consciousness and was unable to read the barometer.

6 SEPTEMBER

1879 The Telephone Company Ltd opened the first public British telephone exchange in Lombard Street, London using Edison's system. The service was in effect an exclusive club, to which members paid a subscription - hence the origin of the term "subscriber."

7 SEPTEMBER

2014 Earth had a near miss when Asteroid 2014 RC made a close approach at 39,900 km. Phew.

8 SEPTEMBER

1930 The Minnesota Mining & Manufacturing Company (now known as 3M) began marketing the first waterproof, transparent, pressure-sensitive tape after employee Richard Drew figured out how to coat strips of cellophane with adhesive.

Initially sold by the St. Paul, Minnesota, company as a moisture-proof seal for bakers, grocers and meatpackers, the product quickly got repurposed during the Depression by money-strapped consumers who used the tape as a cheap home-repair tool.

According to legend, "Cellophane Tape" picked up the "Scotch" tag when a St. Paul car dealer became annoyed because the cellulose ribbons originally only had adhesive on the borders. Slagging 3M for being stingy, he invoked Scotland's penny-pinching reputation and dubbed the product "Scotch tape."

9 SEPTEMBER

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

10 SEPTEMBER

1990 Archie, a tool for indexing FTP (file transfer program) archives and allowed people to find specific files, was launched. It is considered to be the first Internet search engine.

11 SEPTEMBER

1940 The first public demonstration of remote computation occurred during a meeting of the American Mathematical Society at Dartmouth College, USA. Bell Laboratories' researcher George Stibitz set up a terminal that allowed conference attendees to perform remote calculations over telephone lines.

12 SEPTEMBER

1940 The entrance to the Lascaux Caves was discovered by 18-year-old Marcel Ravidat while looking for his dog.

13 SEPTEMBER

1826 The first rhinoceros to be exhibited in the USA was shown at Peale's Museum and Gallery of the Fine Arts in New York City. An advertisement described *"its body and limbs are covered with a skin so hard and impervious that he fears neither the claws of the tiger nor the proboscis of the elephant. It will turn the edge of a scimitar and even resist the force of a musket ball."*

14 SEPTEMBER

1905 The First International Tourist Trophy, an automobile motor race, was held on closed public roads along the Highroads Course on the Isle of Man, Great Britain. This was the first time that what has become known as the RAC Tourist Trophy, making it the longest lasting trophy in motorsports.

15 SEPTEMBER

1947 The Association for Computing Machinery (ACM) was founded.

16 SEPTEMBER

1884 American ophthalmologist, Carl Koller, first used cocaine as a local anaesthetic to immobilize a patient's eye for surgery. Koller recognised this use when he noticed that cocaine had a numbing effect on the tongue.

17 SEPTEMBER

1971 RCA's Board of Directors announced its decision to close its computer systems division (RCA-CSD), which would be written off as a $490 million company loss. RCA, founded as the Radio Corporation of America in 1919, had tried to compete with IBM in the mainframe computer market, but was ultimately unsuccessful.

18 SEPTEMBER

1927 Columbia Phonograph Broadcasting System went on the air with 47 radio stations. However, the radio network lost money in its first year. The radio network was sold and renamed The Columbia Broadcasting System (CBS), and still exists.

19 SEPTEMBER

1991 Ötzi, the Iceman, a Stone Age wanderer and the most ancient human being ever found, was discovered in the Similaun glacier in the Ötzal Alps on the Italian-Austrian border.

20 SEPTEMBER

1967 The Queen Elizabeth II, often referred to simply as QE2, is a floating hotel and retired ocean liner built for the Cunard Line, was launched by Queen Elizabeth

September

continues from page 63

II. She used the same pair of gold scissors her mother and grandmother used to launch Queen Elizabeth and Queen Mary, respectively.

21 SEPTEMBER

– aka Wife Appreciation Day

1945 Henry Ford ceded the Ford company Presidency to his grandson, Henry Ford II and went into retirement.

22 SEPTEMBER

1937 This was the first International Hobbit Day and the birthdays of Bibo and Frodo Baggins, characters created by J. R. R. Tolkien.

23 SEPTEMBER

1879 American inventor Richard Rhodes received a patent for a hearing aid called the Audiphone. The device consisted of a fan made of a hard rubber material that used the operator's teeth and jaw bone to conduct sound vibrations and improve hearing.

24 SEPTEMBER

1991 Children's author Theodor Seuss Geisel, better known as Dr. Seuss, died at the age of 87.

25 SEPTEMBER

1878 Dr. Charles Drysdale, a physician at the Metropolitan Free Hospital, wrote in The Times newspaper in Britain warning against the use of tobacco. He expressed concern about *"the enormous consumption of tobacco in all European states"* and estimated that £15,000,000 was spent annually in Great Britain on tobacco!

26 SEPTEMBER

2008 Yves Rossy, a Swiss military-trained pilot and an aviation enthusiast, leapt from a helicopter at an altitude of 2,500 metres over Calais, France. He then crossed the English Channel with a single jet-powered wing strapped on his back, wearing only a helmet and a flight suit for protection. Reaching speeds of over 200 km/h and ended off with celebratory hoops.

27 SEPTEMBER

1825 The Stockton and Darlington Railway (S&DR), a railway company that operated in north-east England from 1825 to 1863, was officially opened. This was the world's first public railway to use steam locomotives.

28 SEPTEMBER

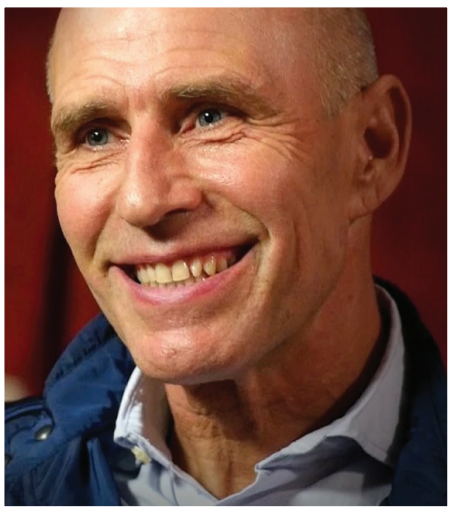
1968 The Beatles' single "Hey Jude" hit the top of the US Billboard Hot 100 for nine weeks. The song is over seven minutes long and was the longest song ever to hit No. 1 in the USA, a record it holds to this day.

29 SEPTEMBER

2007 Calder Hall (Cumbria, England), the world's first commercial nuclear power station, was demolished in a controlled explosion.

30 SEPTEMBER

2016 Two Van Gogh paintings, with a combined value of $100 million were recovered after having been stolen in December 2002 from the Van Gogh Museum in Amsterdam.



= Earn CPD Credits

calendar

SEPTEMBER | OCTOBER 2018

SEPTEMBER 2018

17 - 19	Fundamentals Of Medium Voltage Protection	Johannesburg	roberto@saiee.org.za
17 - 20	SAIEE Bernard Price Memorial Lectures	Nationwide	geyerg@saiee.org.za
18 - 21	Advanced Microprocessor Based Power System Protection	Johannesburg	roberto@saiee.org.za
19	Incident Investigation & Management	Cape Town	khuvutli@saiee.org.za
26	Road to Registration	Johannesburg	roberto@saiee.org.za
27 - 28	Design of Economical Earthing Systems for Utility Electrical Installations	Johannesburg	roberto@saiee.org.za

OCTOBER 2018

9	Substation Design and Construction	Cape Town	khuvutli@saiee.org.za
10 - 11	Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
17 - 19	Operating Regulations for High Voltage Systems for Authorised Persons	Johannesburg	roberto@saiee.org.za
24 - 25	Fundamentals Of Power Distribution	Johannesburg	roberto@saiee.org.za
23 - 24	SA Energy Storage & Smartgrid Conference	Johannesburg	www.energystorage.co.za
24 - 25	Writing Electrical Specifications	Johannesburg	roberto@saiee.org.za
26	Annual SAIEE Banquet	Midrand Conference Centre	geyerg@saiee.org.za
31 - 1	High Voltage Testing And Measurement	Johannesburg	roberto@saiee.org.za

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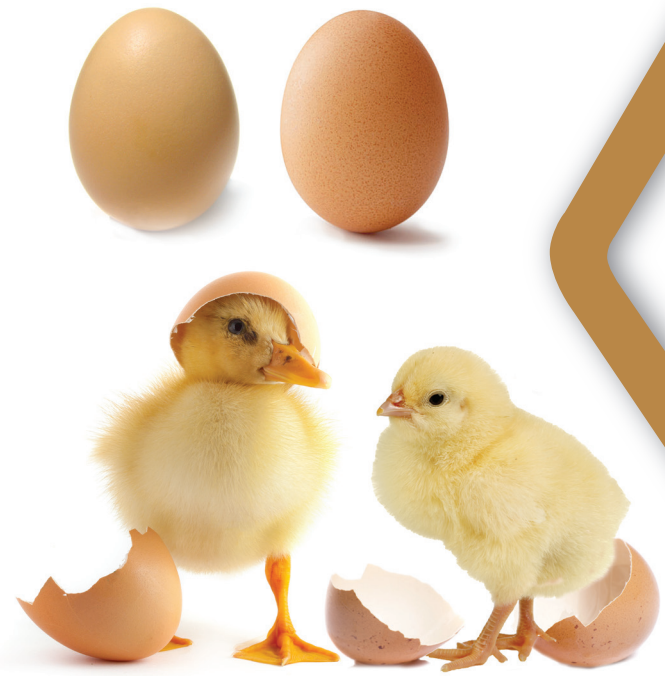
www.energystorage.co.za

Cu

Copper Development Association Africa

Copper Alliance



They may look alike but they're definitely not the same

In electrical applications, copper alloys have different purposes and not all alloys are 'born' equal

Copper is the ideal material for electrical applications because its strength, ductility and hardness make it suited to operating temperatures of up to 100°C (210°F). But ... for many other high-end applications, such as busbars, the specific demands of electrical technology require the copper to have much higher mechanical properties so that it can be used at elevated operating temperatures while still retaining the specified conductivity.

Using uncertified copper can have catastrophic and very costly consequences.

Tip from the Copper Development Association Africa

Only buy copper from reputable suppliers – if it's cheap, it's probably nasty. Use only registered electrical contractors.

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