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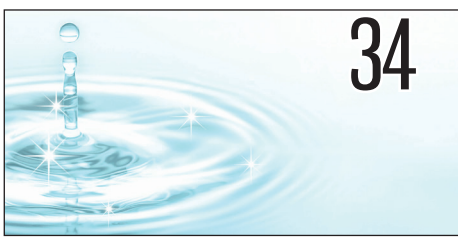

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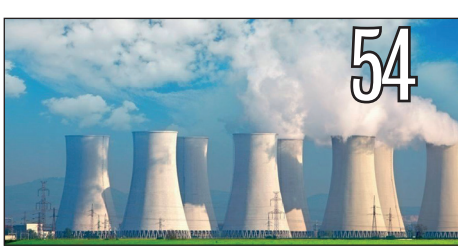

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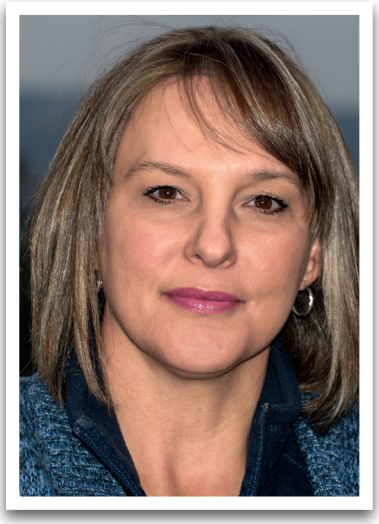

This issue of **watt**now features Power Engineering. To bring you something new, since I have featured this theme before, I did some homework. Power engineering, also called power systems engineering, is a subfield of electrical engineering that deals with the generation, transmission, distribution and utilization of electric power, and the electrical apparatus connected to such systems.

In this issue, I published three fascinating feature articles. The first, on page 24, "Strengthening The Southern African Power Pool With Small Modular Nuclear Reactors" discusses that the power pool serves twelve countries having a combined population of 260 million people. The installed capacity exceeds 50 GW's with energy consumption over 400 TWh per year. The energy mix consists mainly of thermal coal in the South (South Africa) and hydro in the North (Congo and Zambezi Waters).

On page 34, we tackle water security in South Africa, with the article "Developing Small Modular Nuclear Reactors For Water Security In Africa". The challenge of scarcity of water in Africa is access to adequate water resources. Large quantities of energy are required for desalination of seawater. Similarly, large pump stations are needed to move the freshwater from the rivers to the customer load centres.

Our last feature article "Quality Standards for South Africa's Carbon Emissions" focus on the fact that the United Nations Sustainable Development Goals, Agenda 2030, entitled "Transforming our World" has tabled aspirations for urgent action on climate change. COP 24, held in 2018 in Poland, wants greater urgency of action from all countries in managing carbon emissions as a prime contributor to human activity impact on climate change.

The next wattnow Tech Talk will take place on the 23rd of July 2020 at 13h00. Watch out for the announcement.

This online version of **watt**now is interactive. So, on the contents page, click on the page number of the article you are interested in, you will be taken directly to the page. When you are done, select the endnote (wn) which will return you to the contents page.

Here's the June issue,
enjoy the read!

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We have to adapt to a 'new-normal'

SY GOURRAH
2020 SAIEE PRESIDENT

The COVID pandemic has evolved further, and although we are almost at the end of June, there is still a lot of uncertainty. We are at Level 3 with a few more relaxations in terms of lockdown regulations in specific sectors.

We have managed to schedule several webinars. This included the Asset Management Series, The Presidential Invitation Lecture on the "Anomaly of a supplier of last resort in the new distributed, deregulated, electricity supply model by David Nicholls, and the wattnow Technical Talk on Cochlear Implants as part of our Biomedical theme in the last issue. We are currently hosting, for the first time in SAIEE history, several online CPD courses, and we have a webinar on BlockChain Technology scheduled for the 30 of June.

Technology has evolved in the COVID-19 world, and SAIEE is continuing to provide webinars and courses under the circumstances. Business continuity must still be of priority, and we encourage you to continue paying your membership fees. We have risen to the challenge under the very trying times and where our budget is under serious threat. We are focusing on prudent financial management and tracking the diminishing income.

Our resilience to cope with the crisis has been phenomenal, and we will bounce back stronger. Adversity has created opportunities to collaborate with technical, learned societies. Let us not forget that we are still experiencing unprecedented economic, health and humanitarian crisis with no end date in sight as we look forward to the midyear budget speech by the Minister of Finance. The decrease in economic growth this year, the expansion in the budget deficit and the impact of the rescue packages will have an effect. There is a great deal of uncertainty, uneasiness, trauma and stress with most of us adapting to the new normal.

Safety is of paramount importance to us, and we emphasise that you stay safe and be responsible during this global pandemic.

Take care of yourself and your family and be safe. wn

Kind regards

S Gourrah I SAIEE President 2020
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Two major wins for Aurecon at SAPSA Awards

Tony Igboamalu
SAPSA Young Engineering Professional of the Year.

Engineering, design and advisory company Aurecon which is rebranding as Zutari, has scooped two major awards at the 2019/2020 South African Professional Services Awards (SAPSA), sponsored by Sanlam and W. Consulting.

Aurecon was named Engineering Firm of the Year, while Tony Igboamalu was recognised as Young Engineering Professional of the Year.

Professionals from a wide range of companies were set to gather at a gala dinner in Montecasino Ballroom on the evening of 19 March. However, due to the Covid-19 pandemic, the SAPSA Awards dinner was indefinitely postponed.

The organisers subsequently undertook to progressively announce the winners for the 2019/2020 edition prior to hosting a future gathering for all finalists and guests. This marks the fifth edition of the awards, following a rigorous process of determining winners based on strict criteria.

The judges felt that Aurecon has positioned itself as a leading engineering firm in both the local and global context. Its latest Level 1 B-BBEE rating shows that it takes transformation seriously, while its CSI commitment exceeds the construction industry's requirements.

Igboamalu's latest accolade follows him being highly commended in the Young Engineer of the Year category at the Consulting Engineers South Africa (CESA) Aon Engineering Excellence Awards. *"It is impressive that at such a young age he has completed his doctorate, demonstrating a commitment to enhancing his knowledge in his field of engineering,"* the judges noted.

"In addition, his research and work indicates that he is 'walking the talk' in seeking to improve the lives of Africans through enabling access to arguably the most critical resource, namely potable water. Finally, it is heart-warming that he participates in the mentorship of university students and STEM skills transfer to younger scholars in informal settlements," the judges' citation read.

Igboamalu says he is extremely gratified at receiving the award, as it represents recognition from his peers in the engineering fraternity for his work in highlighting the link between poverty alleviation and water supply.

"I am thankful to SAPSA for the recognition, as well as to Aurecon for giving me the platform to go this far. I believe strongly in mentorship, and this award will assist me greatly in this regard."

"Aurecon embraces inclusivity as we look to grow and prosper in Africa. Importantly, this means that not only do we acknowledge our diverse perspectives and experiences, but we see the advantage in the unique strengths and talents that each and every one of our valued employees brings to the table," CEO Gustav Rohde comments.

"It is therefore with great pride that we acknowledge the incredible recognition bestowed upon Tony, as it is such a strong reflection of the values of Aurecon itself. We wish Tony all the best for the future, and look forward to many more amazing achievements and milestones as he continues to grow and prosper," Rohde highlights. wn

Dust extraction specialist revolutionises its global range of stationary equipment

Dustcontrol UK has entered a new era of smart technology with the launch of two comprehensive control systems that are set to cover up to 90 per cent of its stationary units worldwide.

Both high on energy-saving and environmentally friendly, the new Smart Panel and Base Panel will be a gamechanger in the way its stationary machines are operated, offering a high degree of functionality and automation as standard.

The Base Panel is a standardised and configurable product with a clear and simple definition of functions and built-in frequency drive. It has been developed as a compact and efficient control system suitable for Dustcontrol UK's central vacuum systems.

Taking Dustcontrol UK into the era of industry 4.0, the Smart Panel comes in a compact, standardised format and delivers a configurable solution suitable for the majority of Dustcontrol's more complex installations. It will be used in combination with an energy-efficient, externally mounted frequency converter for starting and controlling the motor.

Smart Panel is delivered ready to be connected to Dustcontrol UK's cloud-based solution, enabling data logging, monitoring, and control of the system. Connection can be with either a fixed connection or a 4G connection via a SIM card. The comprehensive solution including service and maintenance will be available this autumn. wn

For further information on Dustcontrol UK's products, email: sales@dustcontrol.co.uk.

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INDUSTRY AFFAIRS

A 'smart collaboration' to globally advise and support public-private-partnerships 'in distress'

As public-private-partnerships (PPPs) around the world grapple with the impact and implications of the COVID-19 pandemic and the consequent economic fallout, project, engineering, operations and management advisory firm Engenamic is pleased and enthused to announce its international collaboration with leading Washington D.C. -based infrastructure development practitioner and PPP navigator/procurement specialist David Baxter.

"This synergistic collaboration brings together and collectively leverages Engenamic's broad-based 'troubleshooting and fixing' and strategic advisory expertise, together with our ability to understand and integrate the 'big picture' scenario (technically and non-technically), with the international development and PPP sector advisory expertise of David Baxter" says Engenamic CEO and Principal Advisor Ian McKechnie. *"It provides a strong value proposition to clients globally in the PPP sector".*

"With an initial collaborative focus on advising and supporting PPPs globally that find themselves in distressed conditions and situations, we can collectively add significant value through our constructive, independent and objective advisory facilitation and support" McKechnie says.

"Particularly pertinent to the times, these advisory and support services are well suited to the 'virtual space', and we are geared to provide them in this manner worldwide, leveraging technology, and bridging physical, country and time-zone barriers."

David Baxter notes that he recently conducted an international survey in the PPP sector, which, with responses from both the public and private sector across 69 countries, provided valuable and important insights. *"The responses highlighted challenges and issues being faced by PPPs globally. Some of the sectors identified as particularly vulnerable or affected at present include transportation, tourism/leisure, power/energy, healthcare, education, water & sanitation and agriculture".*

Baxter adds that *"particularly pertinently, the responses highlighted the need for support in assisting PPP projects/programs to sustainably weather and recover from the impacts of the COVID-19 pandemic. This includes technical/sector expertise support to address both immediate and future impacts".*

Noting these viability, sustainability and resilience challenges, David Baxter comments that the collaboration between himself and Engenamic is strongly placed to collectively provide such technical/sector expertise advisory support to PPP projects and programmes internationally.

With a growing potential of adversarial disputes, and/or of failure or other undesirable situations and outcomes quickly developing, all of which are potentially very costly and detrimental to parties, McKechnie comments that a 'smart move' in the circumstances,

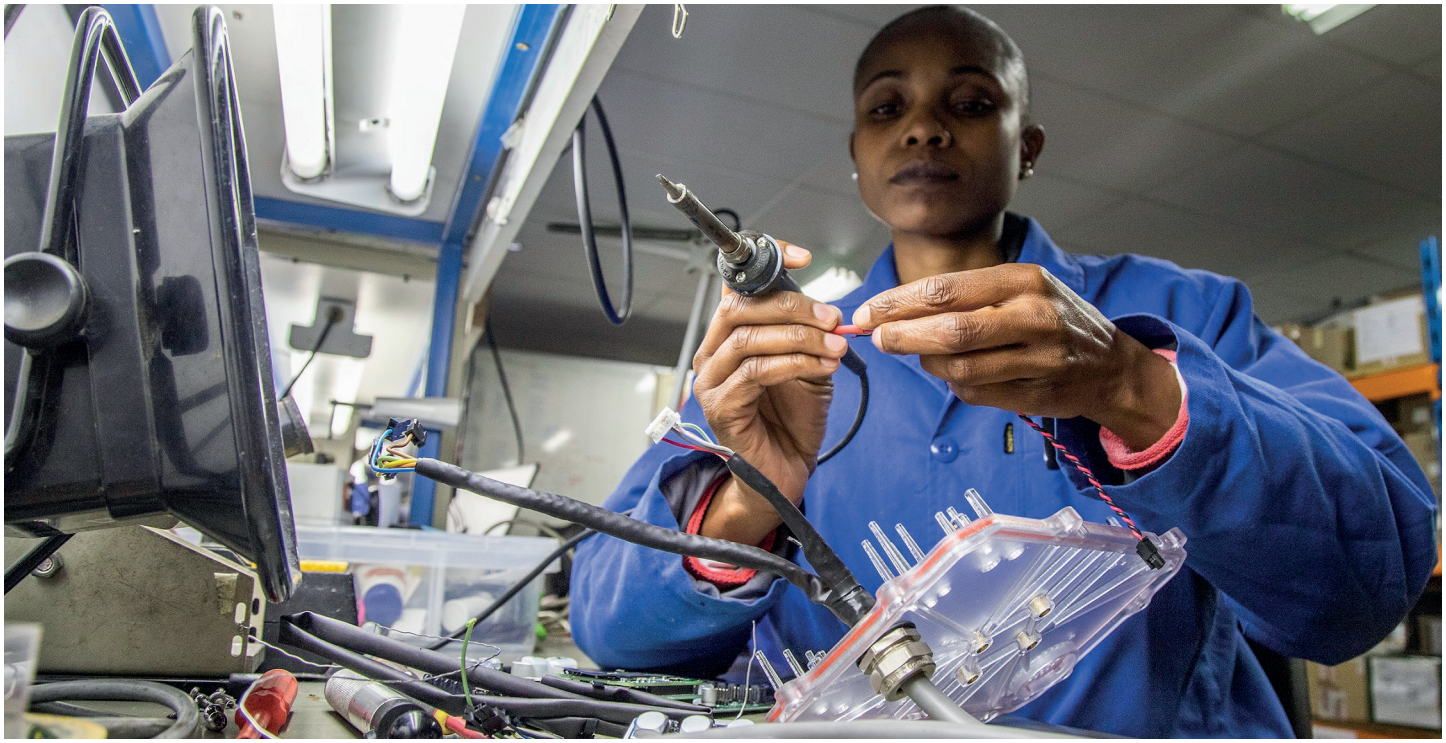
David Baxter
Infrastructure Development Practitioner & PPP Procurement Specialist

and certainly at least in the first instance, would be for the parties to strategically adopt a 'pragmatic sustainability' and dispute-avoidance approach and intervention, *"seeking the more 'win-win' and sustainability types of scenario outcomes".*

McKechnie adds that *"Such an approach creates opportunity - for those willing to embrace it - to evaluate, rethink, reset, change and find positive, broadly-beneficial and, perhaps most importantly, sustainable and resilient ways forward. To move forward 'smartly'!"*

David Baxter concurs, and he and Ian McKechnie both note and emphasise that parties should be encouraged to start such sustainable and resilient interventions and processes as soon as possible, and that these processes would benefit from external and independent, objective facilitation and support. wn

BOOYCO BOOSTS IN-HOUSE ENGINEERING TEAM



Booyco Electronics has further strengthened it capacity to deliver solutions.

At the forefront of technological innovation in collision avoidance systems (CAS), Booyco Electronics is investing heavily in its expertise by actively growing its engineering department in the coming months.

"Engineering the solutions that will ensure safer working places is at the heart of our business," says Pieter Wolfaardt, chief operations officer at Booyco Electronics. *"Collision avoidance is a field that demands highly technical electronic devices as safety deterrents, and we are continually strengthening our capacity to develop and deliver these solutions."*

As the standards governing collision avoidance in the mining industry become more stringent, the technologies serving this need are evolving rapidly as well, says Wolfaardt.

Booyco Electronics has a large market share in South Africa, and its learnings from implementation across many mine sites are incorporated in its solutions offerings further underpinning the company's commitment to industry best practice principles.

While engineering designs around Booyco products are often customised to meet specific customer and site applications, these are fully aligned with all legislative requirements for the South African mining industry including SANS Codes. The Booyco product range also conforms to the guidelines laid down by the Earth Moving Equipment Safety Round Table (EMESRT).

"It is our engineering team that develops the product offerings for our customers' requirements, and the development process never ends," he says. *"They are involved in research and development, extensive testing, and ongoing upgrades."*

Wolfaardt highlights that the company is looking ahead to the kinds of technologies that will be required by 2025, and is aligning itself with that vision. All three of the company's main product lines – CWS, CXS and PDS – are receiving constant attention and improvement.

Among the most important recent technical achievements has been a 'scalable' design that suits a wide range of customer requirements without them having to change hardware on the equipment. Rather, the firmware or the software can be updated on a continuous basis.

"Our increased engineering capacity will support customers who are still getting to grips with changing CAS requirements, especially those mines who are new to CAS," he says.

INDUSTRY AFFAIRS

Rumored return of load-shedding confirms need for implementation of IRP2019 as part of COVID19 response

The SA Photovoltaic Industry Association (SAPVIA) has welcomed the government's update on plans to implement the Integrated Resource Plan 2019 (IRP2019) which will contribute to the country's Covid-19 economic recovery package.

This comes hot on the heels of warnings by Eskom of possible power disruptions due to power-station breakdowns.

"The IRP's biggest opportunity is in low cost electricity which would create additional operational and construction jobs and only consistency will open the prospect for domestic manufacturing of renewable components. Embedded solar energy can also contribute to ensuring energy security in the short and medium term which is now even more critical if we go into winter and there is a possible return of load-shedding," says SAPVIA COO Niveshen Govender.

The solar industry has a policy target to generate 6GW of energy by 2030 and will contribute to the procurement of 2000MW of distributed energy by 2024. The Head of the IPPO confirmed that this procurement will shortly commence.

"Implementation of the IRP is a valuable tool to kick-start our economic response to the pandemic, and can go a long way to giving our country the stability and certainty of a reliable power source. Our economy and our future simply cannot afford the uncertainty that comes with the specter of possibly again going through load-shedding," says Govender. wn

Ref Tools keeps HVACR professionals on the cutting edge

As the cooling industry continues to evolve, HVACR professionals need tools, guidance, support, and information that keep them on the cutting edge. Ref Tools puts all of that in the palm of their hand.

Danfoss announced today that Refrigerant Slider, their popular P/T calculation app that has over 2 million downloads, will transform into Ref Tools, an essential, all-in-one mobile app for air conditioning and refrigeration technicians. Ref Tools will give HVACR professionals the tools, guidance, support, and information to keep them on the cutting edge. Download the Refrigerant Slider today to automatically get all the new tools and features. wn

Coega kick starts NMB economy with projects under construction – 437 construction jobs created with the easing of lockdown regulations

The Coega Development Corporation (CDC), developer and operator of the 9003ha Coega Special Economic Zone (SEZ) has been hard at work with the relaxation of the government regulations on SARS-COV-2 pandemic, allowing construction activity to commence under Alert Level 3.

The Coega SEZ saw several SEZ projects worth billions of rands coming to a grinding halt in March due to the COVID-19 pandemic and subsequent correct actions declaring a national lockdown by the South African government.

"We can't express enough the need to resume economic activity in the SEZs throughout the country as the COVID-19 pandemic has undoubtedly had a devastating effect across the entire economic value chain," says Dr Ayanda Vilakazi, CDC Unit Head of Marketing & Communications.

The CDC welcomes two significant construction projects that have resumed construction. This has brought the much needed economic activity to the SEZ and Nelson Mandela Bay (NMB) economy. Two construction projects at the Coega SEZ are the Multi-User Facility phase 2 (R60 million investment & 280 construction jobs) and the Fruit Terminal Facility (R244 million & 157 construction jobs), valued at R304 million accumulatively, highlights Dr Vilakazi. wn

Schneider Electric Extends Strategic Partnerships with AVEVA, Lenovo and Stratus to Enable IT/OT Convergence

Schneider Electric, the leader in digital transformation of energy management and automation, has announced the expansion of its partnerships with leading technology companies to address the convergence of IT and OT.

Bringing together system integrators with IT solution providers to build integrated industrial edge computing solutions, the expanded partnerships have resulted in the immediate release of three programs including: new reference designs, co-developed with AVEVA, and integrating solutions from Lenovo and Stratus; a learning path for system integrators; and a collaborative online community for learning and sharing opportunities within Schneider Electric Exchange. The industrial edge programs from Schneider Electric empower system integrators to expand their value to the end user, enabling their customers' industrial digital transformations.

"The smart factory is becoming smarter. Our expanded partnerships and new industrial edge programs empower system integrators to leverage their domain expertise and become IT/OT convergence specialists and meet these needs for their customers," said Philippe Rambach, Senior Vice President, Industrial Automation, Schneider Electric. *"We know that smart manufacturing is driving an unprecedented wave of IT technologies into industrial spaces. As companies leverage AI, robotic processing automation, and more, they will require edge computing solutions to reduce latency and enable resiliency, while ensuring privacy and security, and addressing important data and bandwidth requirements."*

For industrial operators to capture the benefits of increased automation, they cannot rely on cloud-technology alone to bring the resiliency and speed demanded by AI, HD cameras and other Industry 4.0 technologies. Local edge data centers are IT infrastructure enclosures/spaces/facilities distributed geographically to enable endpoints on the network. When in industrial environments such as a manufacturing plant or distribution center, this application is referred to as "industrial edge." Analysts have identified the edge as becoming increasingly important.

"The industrial edge is one of the fastest-growing segments of industrial automation and a key driver that is influencing digital transformation," according to Craig Resnick, Vice President, ARC Advisory Group. *"To achieve the shortest possible ROI, manufacturers must properly measure asset performance, rapidly identify any problem areas, and make any crucial changes in real-time that will drastically improve their operations. The industrial edge is where this important on-site data capture occurs, real-time analysis of this data is performed and converted into intelligent information, and then shared with the cloud and throughout the entire enterprise while addressing manufacturers' concerns, such as latency and security for production environments."* wn

INDUSTRY AFFAIRS

Telkom launches app to grow small businesses

As the tough economic environment continues to affect industries adversely, small businesses are hit the hardest. But Telkom Business have good news.

Helping the growth of small businesses in South Africa who have been severely hit by the COVID-19 pandemic, Telkom Business announces the launch of its latest innovation, Yep! on Google Play and Apple's app store.

Yep! is a digital marketplace where customers can safely and confidently search and purchase from small, trusted businesses.

The app is geared toward economic sustainability, creating a long-term future for small businesses.

"Think of Yep! as a 'friend' to small businesses, as it provides a scalable solution to help grow and enhance their reach," says Lunga Siyo, CEO of Telkom Business. *"The COVID-19 pandemic has far-reaching effects, none of which paint a bright future for many businesses and even more so in South Africa where small to medium-sized enterprises form the backbone of the economy."*

Users can easily locate businesses or services they require in their area, request quotes, directly book appointments from the app, view the store online, and review its ratings.

Users can also create their own online store with their own unique branding, upload their list of services to find new customers.
In 2019, small businesses generated more than a quarter of total turnover in business services, trade, community, and both social and personal services, according to Stats SA.

With the current crisis, Treasury projects that more than seven million jobs could be lost as a result. *"Yep! will play a critical role in ensuring the survival of the country's small businesses that we've come so to rely on and help provide and grow the job sector,"* Siyo adds.

Yep! will continuously evolve and will soon boast several feature upgrades that customers can look forward to, including:

- More service categories will be enabled on the platform
- Full fulfilment where customers can book appointment, service providers can complete invoicing and mark job completion
- Online delivery and payment integration

It will also include a bidding section where users can post a service requirement or bid for new business as per customers' requirements and corporate partners.

It is mutually beneficial as small businesses get exposure, customers get convenience, and large corporations can search for SME suppliers.

WHY NOT TRY IT?

Try the Yep! app now by downloading the app from your app store to see how it works and get a better feel for it.
On Yep! small business can sell and buy products and services that will help broaden their customer base and bid for new opportunities. But this is just the beginning - new vendors and exciting features will constantly be uploaded onto the marketplace.

"In this tough times, Telkom Business is excited to pivot and create a solution that will help unlock real opportunities for SMEs. Yep! allows us to create value for customers and secure a different revenue stream for the Telkom Group," ends Siyo. *"At Yep! it is our business to grow small businesses."* wn

DEHN Africa hires new Key Account Manager

DEHN Africa is pleased to announce the appointment of the company's new Key Account Manager, who hit the ground running with his responsibilities despite being hired just as the COVID-19 lockdown began.

Allen Seager has joined DEHN Africa during a time of continued productivity for the business, despite the local uncertainties operating in the country because of the COVID-19 global pandemic and subsequent lockdown.

Seager began working for DEHN Africa on 01 April, just as the lockdown began, but with the support of his team, and through his own initiative, was nonetheless able to get up and running in his new position very quickly.

He explains, *"The way I managed the lockdown period was with the great guidance from our Head of Sales, Florian Voegerl, as well as the DEHN Africa engineering team. I was able to get to know our products in-depth very quickly and thereafter began working on the company's client relationships.*

"I'm a qualified electrician with experience in electrical/ electronic and high voltage test equipment. As the Key Account Manager, I will focus on building relationships according to strategic guidelines, as well as identifying opportunities to increase our sales growth, support our value-added resellers and arrange presentations and seminars to all our clients."

Seager says he was interested in joining DEHN Africa as a company because of the positive attitude and guidance of the team, which allows employees to excel in their careers, as well the company's family dynamic.

Hano Oelofse, MD at DEHN Africa, adds, *"We are very pleased to welcome Allen on board and we applaud him for his great start during extraordinary times! Allen has already shown himself to be a great team player and will be liaising with a number of key areas internally, including the engineering team, management, internal sales, logistics and our value-added resellers. The company is going through an exciting phase and we look forward to having Allen being a part of the DEHN Africa journey."*

ZEST Weg partners with Panaco in Katanga

The Panaco management team at the company's new business premises in Lubumbashi.

As part of strengthening its African footprint, Zest WEG has appointed established local firm Panaco as its value-added reseller (VAR) in the Katanga region of the Democratic Republic of Congo (DRC).

According to Zest WEG's Africa business development executive, Taylor Milan, Panaco is a 100% locally-owned business that has successfully serviced the region for over 40 years.

"Panaco is a well-established and respected company with strong business relationships with nearly all of our current clients," Milan says. "Its business methodology and culture are closely aligned with ours, and this synergy will aid us in supporting our current installed base, client network and growth expectations."

He highlights the increasing importance of local content in the supply of equipment and services across the continent. Zest WEG has prioritised closer partnerships with local firms as a key element of its sustainable growth strategy in Africa.

Milan also emphasises the importance of VARs in this strategy. *"Going beyond the role of just a distributor, a VAR is a local business chosen to promote and support the wide range of Zest WEG's offering. It carries the whole Zest WEG brand into local markets,"* he says.

"Panaco has the ability to assist us in growing the comprehensive WEG product portfolio well beyond our traditional low-voltage motor and drive business," he says. *"It has business facilities in Lubumbashi, Kolwezi and Kinshasa – bringing our services and support closer to customers in this fast-growing region."*

The VAR partnership will provide locally accessible support and skills, substantial stockholding and quality products at competitive pricing; it will also build strong and service-oriented customer relationships, says Milan.

Zest WEG has also appointed DRC firm AEMI as a WEG-accredited repair facility, after AEMI successfully met the demanding OEM standards. The company has a full repair facility in Likasi, and another in Kinshasa. wn

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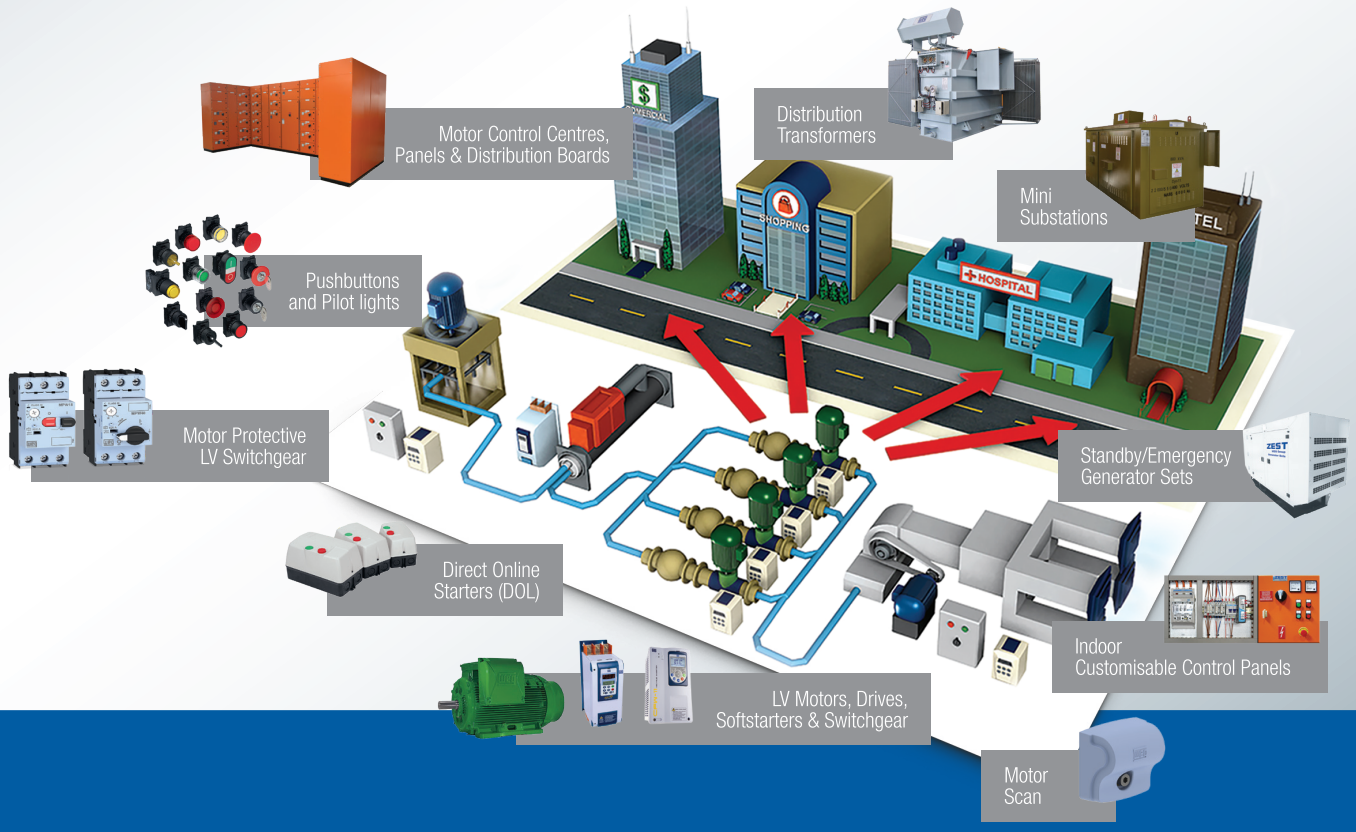

An in-depth understanding of the requirements for HVAC applications, access to quality product solutions and years of experience have ensured that the Zest WEG service offering is fit-for-purpose. From single product installations to individually customised solutions, our latest technology ensures optimal performance, increased reliability and the highest levels of energy efficiency. Reduced maintenance and ease of serviceability assist in lowering the total cost of ownership for operations.

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Trafo Customises Transformers for Renewables and Beyond

A focus on application engineering allows Trafo Power Solutions to supply customised dry-type transformers for a range of sectors including renewable energy.

"We begin at the proposal stage by engaging closely with the customer about the exact application and electrical load," says David Claassen, managing director of Trafo Power Solutions. *"This means that every project gets its own transformer design, so that it is fit for purpose."*

In the case of renewable energy applications, for example, there are some very specific demands that need to be accommodated. A solar power generating plant presents a situation in which a transformer will be energised from zero to 100% on a daily basis.

"This leads to wide fluctuations in temperature inside the transformer which, in turn, causes the resin around the windings to expand and contract considerably," says Claassen. The windings in dry-type transformers are insulated in a cast resin or epoxy material, rather than oil, and rely on air movement for cooling.

"Such fluctuations could result in the resin cracking, so the design must specify the appropriate class of insulation to cope with these conditions," he says. *"We can design our windings for either a Class F or a Class H insulation. In addition, the mixture of the resin is specially formulated to accommodate the duty cycle specific to renewable energy applications."*

The standard design – using Class F – can deal with temperatures up to 155 degrees Celsius. For many of Trafo Power Solutions' low voltage and high voltage installations around Africa, the design includes a resin mix to Class H specifications. This gives it the capacity to withstand temperatures of up to 180 degrees Celsius.

Another aspect that needs to be considered for renewable energy applications is the non-linear load that inverters add to the mix. The transformers need to be designed with a K-Factor much higher than used for standard distribution type loads as well as the addition of an electrostatic shield between the primary and secondary windings, to eliminate potentially damaging leakage currents.

Claassen notes that dry-type transformers are being increasingly specified for demanding applications such as renewable energy plants, instead of conventional oil transformers.

A 400V/22kV step-up transformer designed for renewable energy applications.

"With an oil-cooled unit, the temperature fluctuation arising from these rapid and regular energising and de-energising cycles brings its own challenges," he says. *"In particular, it causes more gases to be emitted within the transformer tank, which leads to a variety of problems."*

The cast resin material used in Trafo's dry-type transformers meets the specifications of the International Electrotechnical Commission (IEC) for fire class F1. The units therefore present minimal fire risk, allowing them to be used indoors safely, and without environmental protection like bund walls for potential oil spills.

Claassen says dry-type distribution transformers are fast becoming a more suitable alternative to oil transformers, especially in the distribution power range between 50 kVA size and 10 MVA, although Trafo Power Solutions is able to supply dry type transformers up to a power rating of 25MVA. wn

A multi-winding cast resin transformer which includes an electrostatic shield specially designed for complex load conditions associated with renewable energy applications.

Torquing about advanced pump controller

Factory automation continues to develop year on year and pumps are increasingly required to supply real time operating data to control networks so that their performance can be monitored and adjusted to meet constantly changing production requirements.

Hard wiring a sensor into a pump's rotating drive shaft usually requires the use of a delicate slip ring, but an alternative solution is to use a non-contact radio frequency detector, as Mark Ingham of Sensor Technology Ltd in the UK explains.

As industry strives to become more and more productive, technologies that support smart factories, Industry 4.0 and the Industrial Internet of Things, are being used with increasing frequency on the shop floor. The potential of these and other developments to improve manufacturing quality and efficiency over time is almost limitless.

However, such advances are not without their difficulties; one such being the need to connect machines and equipment such as pumps, mixers and conveyors to the control computers. Wiring up one machine is not a great task, but a highly automated factory will have literally hundreds or even thousands of them, so the task becomes very considerable.

Thus even a moderately sized factory has to employ a significant number of electricians and engineers who spend their days wiring and rewiring equipment. It follows that, if the amount of time spent on wiring and installation could be reduced, the factory could reduce its operating costs significantly.

One of the most time consuming tasks is fitting torque sensors to rotating equipment, as this requires the use of fiddly and fragile slip rings. However, torque is a key performance indicator. For instance, a gradual increase in a pump's torque may suggest increasing flow to compensate for growing leakage; a sudden increase may indicate a blockage downstream of the pump, while a sudden reduction may be due to an upstream blockage.

So in automated plant it is well worth measuring torque, but can fitting a suitable sensor be made quicker, easier and therefore more cost effective?

The answer to this question is 'yes'. TorqSense is a wireless sensor that replaces the need for physical wiring and slip rings with radio wave communications. Fitting a TorqSense typically takes about one-fifth the time required for a conventional hard wired

transducer, but how do they work?

A shaft under rotary load will twist very slightly along its length, in proportion to the magnitude of the load. TorqSense measures this twist in real time and its electronics converts the reading into a torque value.

TorqSense transducers use two Surface Acoustic Wave (SAW) devices, which are attached to the surface of the shaft. When torque is applied to the shaft the SAWs react to the applied strain and change their output. The SAW devices are interrogated wirelessly using an RF (radio frequency) couple, which passes the SAW data to and from the electronics inside the body of the transducer.

Sensor Technology's Mark Ingham explains: *"All you have to do is set up a TorqSense is glue the SAWs to the shaft, fire radio waves at them and monitor the waves that are reflected back. The SAWs are distorted in proportion to the twist in the shaft, which in turn is proportional to the level of torque. The frequency of the reflect waves is changed in proportion to the amount of distortion and electronics within the TorqSense analyses the returning wave and feed out torque values to a computer screen.*

As the TorqSense method does not require contact with the rotating shaft it offers complete freedom from the slip rings, brushes or other solutions found in traditional torque measurement systems. TorqSense devices also have a high immunity to magnetic forces, allowing their use in, for example, motors where other technologies are very susceptible to electronic interference."

BLUETOOTH

Conceptually Bluetooth is very similar to TorqSense. It is a wireless technology that enables data exchange over short distances and, like TorqSense, its transmits using radio waves. It is commonly found in hands-free phones and other mobile devices, so is used by many people on a daily basis. In the engineering and industrial worlds, it is often favored as a wireless alternative to RS232 data cables and can connect several devices simultaneously.

Sensor Technology's new Bluetooth module creates totally wireless solutions for torque measurement. In use the module simply plugs into the TorqSense's existing 15 way 'D' digital lead connector. As well as collecting torque signals, the modules can provide power to the TorqSense transmitter/receiver and provides a USB output for connection to a PC.

Bluetooth/TorqSense will be welcome in cable-dense environments such as automated factories and will enable torque monitoring via any Bluetooth enabled device.

Sensor Technology has also launched an Android app that allows torque parameters to be monitored via a standard mobile phone or tablet, without the need for a PC. wn

For more information: email sales@instrotech.co.za

New storage technology for powering the Fekola hybrid energy project in Mali

On a continent richly endowed with natural minerals, mining is one of the biggest trades in Africa. Remote, energy-intensive and fuel-dependent mine owners are dealing with high energy costs as a result of mining operations for a myriad of practical applications and infrastructure development. To improve power supply at their off-grid Fekola Mine, B2Gold, a Canadian public gold-mining company, has taken to the adoption of storage and energy management technologies.

Wärtsilä is delivering a hybrid solution at B2Gold's Mine in southwest Mali in late 2020. Wärtsilä's GEMS, an advanced energy management system, will integrate, control and optimise a 17.3 MW / 15.4 MWh energy storage system alongside a 30 MW solar PV plant onsite, in addition to the mine's existing 64 MW power generator.

This hybrid storage project is the first of its kind in Mali and the largest in the mining sector, demonstrating the growing case for clean energy and its sustainable and economic potential for mines in Africa and beyond. Its objectives are multiple: It must ensure grid stability, provide energy security, integrate renewable energy assets, and optimise energy production at a fuel-dependent, energy-intensive and remote mining facility.

Risto Paldanius, Business Development Director, Energy Storage & Optimisation, Wärtsilä Energy Business, explains that: *"Hybrid solutions with renewable energy-sourced power operations, are a realistic and effective means for increasing energy reliability and lowering operating costs for the mining sector. These remote locations are ideally suited for hybrid systems. Our extensive experience with islanded grids in various climatic and geographical conditions will help the Fekola mine, and others of its kind, to achieve their sustainability and cost saving goals."*

ADDRESSING HIGH ENERGY USE IN A REMOTE OFF-GRID AREA

The project will hybridise the energy supply of Fekola mine, with a combination of renewables, storage, power generator, and energy management system. Hybridising the power supply at Fekola will reduce the facility's dependence on imported heavy fuel oil, saving operational and transportation costs, as well as reducing greenhouse gas (GHG) emissions.

The main application of the Fekola hybrid project is to provide and maintain islanded grid stability. This means dispatching energy storage and renewable energy generation assets with the right reserve level to maintain high grid reliability for a mine in a remote area with no connection to

any larger grid. GEMS and the storage system combine stable frequency and voltage with the highest utilisation of renewables in a reliable way.

The control and optimisation capabilities provided by GEMS are key to handling large load step changes and variability of renewable energy generation. Wärtsilä's GEMS software will use artificial intelligence as well as automated and forecasted data, including load demand and weather, to optimally operate the system's generation assets and maximise efficiency. Specifically, GEMS can dispatch or draw energy according to conditions; for example, gensets are switched off as solar output increases, later they are restarted based on forecasting. The result: Seamless switches between generation assets.

Further, by enabling energy production optimisation, GEMS ensures the lowest levelised cost of electricity (LCOE) for the Fekola mine. LCOE is a function of lifetime costs divided by energy production, so more efficient energy production and lower LCOE renders long-term savings. For instance, GEMS supports the starting of major mining equipment without the need to bring additional engine generating sets online, allowing operations to maximise the time that gensets are down. As a result, the project is expected to reduce operating costs by more than 7%.

GEMS will integrate and optimise RE generation assets in tandem with traditional fuel-powered gensets to deliver 18%+ of the total site power requirement for the Fekola mine. At the same time, the hybrid project will secure grid stability via microsecond level frequency management, including engine variations, and provide spinning reserves. There is also potential to incorporate additional assets or enable expansion of the PV plant in the future.
Clean energy power generation

Wärtsilä's energy storage solutions are both cost competitive as well as sustainable. For Fekola, project payback is expected in just few years, with projected long-term savings on mining operations to include 13.1 million litres or more of heavy fuel oil per year. The Fekola solution will also drive decarbonisation, with the mine's GHG emissions expected to decrease by approximately 86 million pounds of carbon dioxide emissions per year.

B2Gold is one of the early mining companies to invest in clean energy power generation: *"We chose Wärtsilä because of their experience in the region, and because of their capabilities in designing and managing hybrid plants. We wanted to optimise full electricity generation at the mine using solar and energy storage. A key part of this solution is Wärtsilä's state-of-the-art GEMS technology; it was an easy decision."* explained Jan Clausen, Project Manager, B2Gold

The active adoption of clean energy and storage solutions—utilising greater amounts of renewable energy to dramatically reduce energy costs and dependence on heavy fuel power generation—offers a largely untapped reliable energy alternative for the mining sector. For Fekola, the benefits are vast. Not only will the hybrid project improve power reliability and significantly reduce carbon emissions, but it will also decrease fuel consumption and mining operational costs. wn

Strengthening The Southern African Power Pool With Small Modular Nuclear Reactors

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The Southern African Power Pool operates the world's largest and unique power pool that consists of physical and financial products operating, simultaneously, across monopoly and competitive markets. The power pool serves twelve countries having a combined population of 260 million people. The installed capacity exceeds 50 GW's with energy consumption more than 400 TWh per year. The market is liquid, robust and bullish. The energy mix consists mainly of thermal coal in the South (South Africa) and hydro in the North (Congo and Zambezi Waters).

The emerging energy opportunities are in natural gas (Mozambique) and renewable energy resources of solar, wind and biofuels. Nuclear energy exists and is limited to the two pressurised water reactors at Koeberg, South Africa.

A limitation of the power pool is that of transmission. For the given transmission, congestion is a constraint. Transmission investment is constrained by financial economics; in general, the distance between source and load is significant, in order of hundreds and thousands of kilometres. Past studies have explored the idea of employing high voltage direct current technologies. Such technologies are maturing in the People's Republic of China; 6000 MW schemes operating at 800 kV HVDC and 10 000 MW schemes operating at 1100 kV HVDC are in commercial operation. Aside from South Africa as a single large load, high voltage GW type transmission schemes will not be practical for application across SADC, as large amounts of GW magnitude do not exist.

Small modular nuclear reactor power generation technology lends itself for widespread application across SADC. The power rating of tens and hundreds of megawatts of capacity is ideally suited for the individual customer, a collection of customers as in a load centre and individual country loads. Customers scattered across the region can have access to an affordable and secure electricity supply. Examples of typical loads are a mining operation in Southern DRC, a distribution grid in the City of Gaborone and a country load as in Namibia.

This paper reviews the existing power pool operations and provides planning scenarios for introducing small modular nuclear-powered reactors at selected nodes across the regional grid.

INTRODUCTION

In August 1995, the Southern African Power Pool (SAPP) was established. This was at the SADC summit in South Africa. Member governments of the Southern African Development Community (excluding Mauritius)

signed an Inter-Governmental Memorandum of Understanding (IGMOU) for the formation of a regional electricity power pool.

SAPP has seventeen members. Twelve members are from the national power utilities, two members are independent transmission companies, and three are independent power producers. Four agreements govern SAPP; the IGMOU which enabled the establishment of SAPP; the Inter-Utility Memorandum of Understanding (IUMOU) which established SAPP's management and operating principles; the Agreement Between Operating Members (ABOM) which established the specific rules of operation and pricing; and lastly, the Operating Guidelines, which provide the standards and regulations for operating the power pool.

Committees populated by the membership provide non-executive oversight. The committees consist of Executive, Management and working sub-committees of Planning, Operations, Environmental and Markets. A Co-Ordination Centre located in Harare, Zimbabwe manages the day-to-day workings of SAPP. The SAPP operational budget emanates from the annual membership subscriptions.

The vision of SAPP is to facilitate the development of an electricity market in the Southern African region that provides for both bilateral and competitive trade between member states.

Month	Active Portfolios	Number of Participants	Total Volumes Traded (GWh)	Total Revenue USD million
Nov 2018	11	9 of 17	216,0	11,4
Dec 2018	13	10 of 17	161,0	6,7
Jan 2019	14	9 of 17	122,5	5,1

Table 1: Market Performance for the Period Nov 2018 to Jan 2019

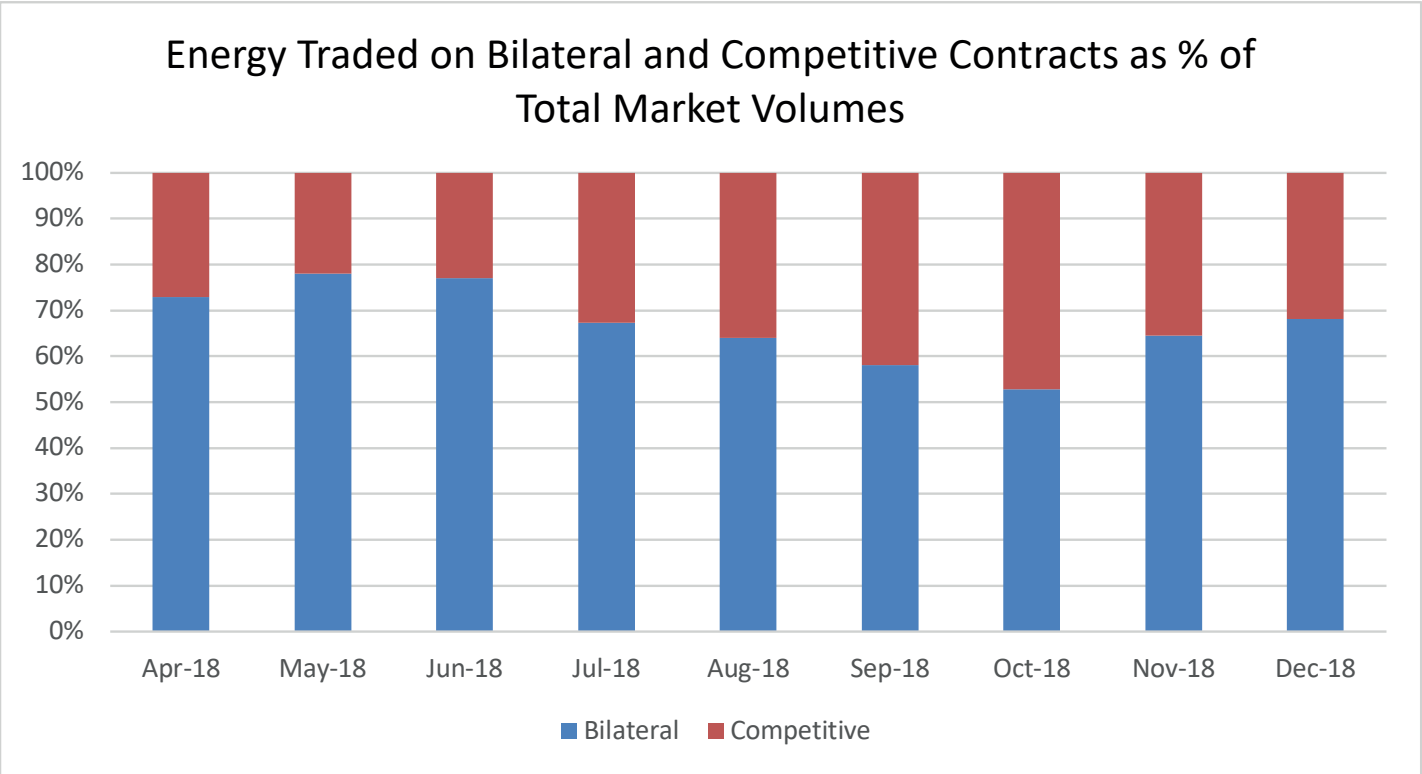
The expectation is one of choice of electricity supply for end-users, to promote the Southern African region as a destination for investment by energy-intensive users and to facilitate sharing of energy resources in sustainable development through sound economic, environmental and social practices.
The electricity market consists of two platforms. These are as follows:

- The Bilateral Market. The bilateral market recognises and manages the contractual relationship between member states and independent participants. The contracts are generally long-term in nature as in standard power purchase or standard power wheeling contracts. The trading terms and conditions are mutually agreed between bilateral partners and include key parameters of volumes, price and transmission security. The energy contracts are generally firm but could consist of interruptible.
- The Forward Physical Market (FPM). Here the SAPP Coordination Centre manages competitive trading amongst the membership for the future time of energy delivery according to the contract specifications.

The following energy contracts are available for the trade;
FPM-Monthly: This trades hourly energy base-load contracts for each of the 24 hours of all days in the next month. The hourly energy base-load contracts for the following time-of-use contracts with different hourly patterns valid for all days in the next month include off-peak hours and non-off-peak hours.
FPM-Weekly: This trades hourly energy contracts for the following time-of-use contracts with different hourly patterns valid for all days in the following week; off-peak hours, peak hours and standard hours
Day-Ahead Market (DAM)- This is the regional market established within the SAPP with the objectives to trade electricity a day in advance of the delivery of such trades and consists of hourly energy contracts

Month	FPM Monthly		FPM Weekly			DAM	IDM		
	Non Off Peak	Off Peak	Peak	Std	Off Peak		Peak	Std	Off Peak
Nov 2018	6,1	2,8	8,6	5,7	2,9	5,7	9,2	6,4	3,3
Dec 2018	7,1	2,7	12,8	5,7	2,7	5,0	8,7	6,2	2,7
Jan 2019	10,9	2,4	13,8	5,2	2,5	4,3	4,7	No Trade	2,1

Table 2: Market Clearing Prices for the Period Nov 2018 to Jan 2019 in US cents/kWh



Graph 1: Market Share for the Bilateral and Competitive Markets

for each of the 24 hours of the following day, or a future day.

Intra Day Market (IDM) - The IDM is a continuous market, and trading takes place every day around the clock until one hour before delivery. Prices are set based on a first-come, first-served principle. The SAPP Market Operator specifies the timing of the hourly energy contracts.

Table 1 provides the market performance statistics, and table 2 shows the market-clearing prices in US cents/kWh. Graph 1 illustrates the market share for the respective and competitive markets [1].

The SAPP 2018 annual report records that 2,154 GWh traded in 2017/18. The competitive market revenue was USD 106.6 m, compared to USD75.6 m in the previous year [2].

For performance enhancement, SAPP requires an increase in market participants from the current 9 - 10 of 17 to all 17 of the full SAPP membership. Three SAPP members remain not connected to the regional power pool due to the absence of transmission. The countries are Angola, Tanzania and Malawi.

The introduction of private sector direct customers, both buyers and sellers, as members of the power pool will enhance trade. Private sector direct customers are available and can emanate from the emerging migration of new energy-intensive mining and industrial customers deep into Africa.

The theme of the SAPP Annual Report of 2018 is "Accelerating the development of energy projects to optimise electricity trading" [2]. This captures the mood and bullishness of the region to grow volumes, to increase trade and turnover and to achieve lower prices and affordable energy for all.

TRANSMISSION AND GENERATION EXPANSION PLANS

The SAPP region demand is growing at a steady 3% per year; another 12 000 MW is forecast in demand growth over the next five years. In the same period, SAPP plans to add another 26,108 MW to its base capacity of 67,190 MW of installed capacity. For the present day, the operational function is at 60,719 MW with demand at 57,762 MW. Table 3 details the SAPP Generation Expansion plan for 2018 to 2022.

SAPP recognises that in the changing environment of global warming, greater emphasis is required in promoting the nexus of energy, water and food security for sustainable development.

Country	2018	2019	2020	2021	2022	Total
Angola	1269	-	-	-	2100	3369
Botswana	-	110	300	-	-	410
DRC	-	-	360	300	-	600
Lesotho	-	20	-	-	-	20
Malawi	112	-	300	18	-	430
Mozambique	130	30	-	-	650	810
Namibia	20	81	175	800	-	1076
RSA	2662	3234	1219	2342	1525	10982
Swaziland	-	12	-	-	5	17
Tanzania	397	-	627	2510	837	4371
Zambia	102	450	891	930	-	2373
Zimbabwe	150	240	600	600	-	1590
Total	**4842**	**4177**	**4472**	**7500**	**5117**	**26108**

Table 3: SAPP Generation Expansion Plan for the Period 2018 – 2022

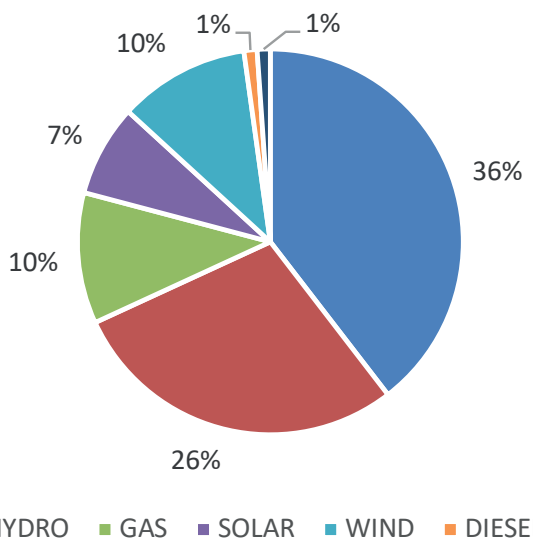
The region has an abundance of natural resources as in renewable energy, freshwater systems and fertile land; the challenge is to have the energy unlock the opportunities at the many the sites that are scattered across the region. The constraint is the transmission and power delivery of great distances for an interconnected grid; or energy storage for the case of off-grid renewable energy engineering solutions.

The South African projections most likely include the conclusion of the Medupi and Kusile Thermal Coal projects.

The absence of a regional integrated resource plan makes the economical and efficient planning of regional generation difficult; the table of projects reflects a summary of the country (national) planning of new generation capacity.

Graph 2 shows the breakdown of primary energy resources for generation expansion.

In the case of cross border transmission interconnections, several projects are under study or project preparation. Project preparation funding is from a collection of development banks and state entities such as the Government of Norway.



Graph 2: SAPP Breakdown of Primary Energy Resources as per the Generation Expansion Plan

The listing of cross border interconnections under study are:

I. Angola – Namibia (ANNA) Interconnection
II. Botswana – South Africa (BOSA) Interconnection
III. Kolwezi – Solwezi Interconnection
IV. Malawi – Tanzania Interconnection
V. Malawi – Zambia Interconnection
VI. Mozambique – Malawi Interconnection
VII. Mozambique – Zimbabwe – South Africa (MOZIZA) Interconnection
VIII. Zambia – Tanzania – Kenya Interconnection and onto SAPP – EAPP Interconnection
IX. Zimbabwe, Zambia, Botswana, Namibia (ZIZABONA) Interconnection

These projects have been on the SAPP Pool Plan for a long time. The main challenge is the absence of bankable long-term bilateral power purchase agreements (PPAs) to fund transmission projects. The region is investigating the establishment of a Transmission Infrastructure Financing Facility (TIFF) based on the strength of the competitive market products to support cash flow repayments and therefore promote transmission investments.

THE COUNTRY AVERAGE ELECTRICITY TARIFFS IN US CENTS/KWH

Table 4 presents the average national average standard prices for electricity in US cents/kWh. Angola has the lowest tariff charge at 3 US cents/kWh. The most expensive tariffs are in Namibia, at 17 US cents/kWh.

SAPP notes that the 2040 Pool Plan, adopted by the Executive Committee in March 2018, shows that it was USD 34 billion cheaper (-22%) over 40 years to go for the integrated regional approach than pursuing national plans, implying that more transmission corridors be developed [2]. However, from table 3, we note that all countries have own generation expansion aspirations with Angola, Namibia, Tanzania, Zambia and Zimbabwe posting totals above 1000 MW in generation expansion capacity.

COUNTRY	STANDARD TARIFF IN US CENTS/KWH
Angola	3
Botswana	7
Lesotho	7,5
Malawi	8
Mozambique	7,5
Namibia	17
South Africa	7
Swaziland	10,5
DRC	4,5
Tanzania	11
Zambia	5
Zimbabwe	10

Table 4: The Country Average Electricity Tariffs in US cents/kWh

Country	2017/18	2016/17	2015/16	2014/15	2013/14
Botswana	147	984	1099	1237	1608
Lesotho	276	252	205	230	122
Mozambique	8326	8120	8281	8360	8314
Namibia	2147	2089	1746	924	1248
Swaziland	839	986	1044	882	741
Zambia	362	352	344	16	143
Zimbabwe	2250	1743	252	108	154
Competitive Markets	921	567	494	243	48
Total	**15268**	**15093**	**13465**	**12000**	**12378**

Table 5: Eskom International Sales in GWh for the Period 2013/14 to 2017/18

THE DOMINANCE OF SOUTH AFRICA IN THE REGIONAL BILATERAL MARKET

South Africa dominates the energy export market. Table 5, from the Eskom Integrated Report for 2018 [3], provides the breakdown of energy exports to the region. Cross-border sales have increased since the recovery of Eskom generation in 2015.

However, sales to Botswana have steadily declined as Botswana recovered its thermal coal generation. Botswana is now almost self-sufficient.

Table 6 provides a summary of all cross border sales and purchases. The volume of cross-border investments was below target. This was primarily due to Cahora Bassa (HCB) reducing its supply because of low dam levels due to the continued drought in that area. For note, the majority of HCB's capacity wheels through South Africa

CATEGORY	5 YR. CUMULATIVE TARGET 2018/23	TARGET 2018/19	ACTUAL 2017/18
International Sales	81 461	14 987	15 268
International Purchases	38 974	8 111	7 731
Net Sales	42 487	6 876	7 537

Table 6: Summary of Eskom International Purchases and Sales

to The Mozambique Transmission Company (Motraco). South Africa only receives 150MW benefit from HCB's power (supply of 1 100MW less the 950MW wheeled to Motraco). This arrangement replaced the exclusive pricing agreement that BHP Billiton's Mozal had shared with Eskom.

THE QUEST FOR NEW GENERATION AND TRANSMISSION INVESTMENTS

Regarding tables 3, 4 and 5, one could assume that those countries with high-energy imports and associated high electricity tariffs will pursue their national generation development plans. The best candidate for new generation investment would be Namibia.

Namibia has high national electricity tariffs and imports the bulk of its electrical energy.

Namibia has the following attributes:
Namibia is located in an arid region and needs large quantities of fresh water. Historically, Namibia has promoted freshwater recovery from wastewater resources. Namibia thus has all the attributes to support their new energy generation investment the nexus of energy, water and waste management.

Namibia has an abundance of natural, renewable energy as in solar and wind resources. Renewable energy resources are available for harvest and employment. The challenge of energy storage sustains. Grid connectivity and energy trading on the regional competitive market platform is a potential solution for the intermittent renewable energy resources. Namibia is also home to the world's largest deposits of uranium; a primary energy resource for nuclear energy. The technological development of small modular nuclear reactors could also open new technology investment opportunities for Namibia.

The small countries of Lesotho and Swaziland present excellent opportunities for new investments in a hydroelectric generation; both countries have an abundance of sites for small hydro development. These include both greenfield and brownfield opportunities.

Mozambique has a unique case; the Cahorra Bassa Hydro-Electric Power Station. The power station is an independent power producer and a member of the regional power pool. The opportunity to develop the North Bank of 1600 MW capacity exists. Mozambique also has many greenfield plans for more power generation using a menu of natural resources of hydro, gas and coal. The bulk of the current capacity is to Motraco, the Mozambique Transmission Company, which supplies 950 MW in bulk to the BHP Billiton Mozal Aluminum smelter in Maputo.

Tanzania is another candidate that brings new opportunities to the market. Tanzania is a member of both the Southern African Power Pool and the East African Power Pool. An investment in Tanzania opens new market opportunities in the South and the East of Africa.

Finally, the DRC, Zambia, Zimbabwe, Malawi and Angola have an abundance of hydroelectric potential and warrants attention to detail. Hydroelectricity has the disadvantage of high capital costs, coupled with the advantage of no charge for energy costs.

Due to a lack of investment in transmission infrastructure, sales are limited, and there exists considerable regional demand, unserved.

The Southern African Power Pool (SAPP) aims to provide reliable and economical electricity supply to each of its members. Access to electricity in all SAPP member states, except for South Africa, is below 45% and as low as 10% in one instance, creating a significant impediment to regional growth.

Coupled with drought, which affected most of the SADC region over the past year or two, the nexus of electricity, water, food security and waste management requires investment for sustainable development.

The opportunity of maximising the employment of renewable energy exists. In the global space, there could be an opportunity to displace a country's carbon emissions with new renewable energy investments in Africa; this aspect warrants further discussion and exploration with the climate change administration at the United Nations.

In summary, new investments are available in the following space in Southern Africa:

a. Electricity reticulation and distribution; "electricity for all towards 100 % grid connectivity"; complimented and promoted by mini-grids, micro-grids, renewable energy and energy storage solutions;
b. Electricity transmission; for new cross border interconnections for bilateral and competitive electricity trading amongst member countries of SADC; and between SAPP and EAPP;
c. Promotion of the Nexus of Electricity, Water, Food Security and Waste Management for new solutions in sustainable development;
d. Electricity generation with primary energy ranging from hydroelectric schemes (large and small), thermal coal and gas, nuclear as in small modular reactors and renewable energy as in solar photovoltaic and onshore wind; and
e. Project financing and co-financing with local and international development banks.

AN EMERGING OPPORTUNITY TO INTRODUCE SMALL MODULAR REACTORS TO THE SAPP ENERGY MIX

The International Atomic Energy Association (IAEA) has published in their 2018 edition the advances in small modular reactor (SMR) technology developments [4]. IAEA recognises SMR as a viable solution to meet energy security for both mature and developing economies.

SMR's have the specific attributes of inherent safety, flexibility in power generation, availability as a heat source for industrial and municipal processes, modularity of design for factory shop fabrication and manufacturing, on-site construction, factory maintenance and "just in time" financing of investments on an as and when required basis, thereby promoting economic affordability.

The extension of duty beyond just electricity generation for application in industrial and municipal processes will deliver both additional revenues and value-added services to the community. Examples of civil services will include the extraction of freshwater from wastewater resources and freshwater from saltwater for coastal communities. Examples of industrial processes include manufacturing as in the paper and pulp industries, in the spinning and weaving industries and the energy-intensive sectors of steel and aluminium makers. The big bonus will be to make large quantities of hydrogen for the emerging new hydrogen and fuel cell-based transportation economy.

In the case of electricity generation, the attributes of generating local to the site of consumption and flexibility of production as in load following make SMR's the ideal partner for large scale renewable energy power generation using solar photovoltaic and on and offshore wind natural resources. In all the examples, the umbrella banner of "natural engineering" encapsulates all the outputs available from this technology.

South Africa has recorded their contributions to the development of SMR technology. Tables 3 details their contribution.

The industry is gathering momentum, and presently, three reactors are under construction. The reactors under construction are as follows:

HIGH-TEMPERATURE GAS-COOLED REACTOR (HTGR) OF OUTPUT 210 MW (E) IN CHINA

HTGRs provide high-temperature heat in the order of ≥750°C. The reactors are suitable for high-efficiency electricity generation, most ideal for cogeneration and load-following capability. Besides, high-temperature for industrial applications is a bonus.

WATER COOLED MARINE BASED SMR OF OUTPUT 70 MW (E) IN RUSSIA

The floating pressurised water reactor presents a unique application for flexible deployment choices in a marine environment, either underwater or on a vessel.

WATER COOLED LAND-BASED SMR OF OUTPUT 30 MW (E) IN ARGENTINA

The design is a light water reactor (LWR) technology, which is the most mature technology as employed in the large power plants of today.

SAPP has options to employ both water-cooled, land and marine-based and gas-cooled technologies.

There are also several reactors at an advanced stage of development and have entered the licensing phase. In

PROMOTER	OUTPUT MW	TYPE OF REACTOR	STATUS OF DEVELOPMENT
Eskom	50	AHTR	Concept Design
Steenkampskraal	35	HTGR	Concept Design
PBMR SOC	165	PBMR	Detailed Design/ On Hold

Table 3: Listing of South Africa's Investment in Small Modular Reactors

particular, we note that in the United States of America, given that the large reactor industry is in sunset mode, the small reactor industry is in sunrise mode. Land-based water-cooled reactors of a mature technology are under development at two sites; mPower has 2 x 195 MW units under construction, and NuScale has 12 x 50 MW units under development.

The net benefit of SMR's lies in the modularity, multiple duty application and "just in time" financing. Thus, an emphasis going forward is that one should invest in "informed buying of technology" rather than "research and development of technology". Soon, there will be many firsts in research and development, and the experiences will be available in journal papers and library textbooks.

INFORMED BUYING OF TECHNOLOGY

Strategically, reported buying of technology is closely associated with people development and lends itself to closer workings with academia as in student development from undergraduate to a postgraduate qualification. There will be generous funding from government resources. Policies in association with the Ministry of Education should be developed and promoted. This strategy augurs well with the international call for global investment in sustainable development and human capital; all in synchronism with efforts to mitigate climate change, global warming and people-friendly environmentally conscious construction. This strategy will be welcome by the general community, who are the customers of service delivery.

Investing in informed buying of technology rather than intensive research and development makes easier the open-source workings amongst all stakeholders. The experience of South Africa's Pebble Bed Modular Reactor Research and development refers. Here, Eskom decided after almost a decade of investment to stop work. The investment made was effectively lost or stranded. The investment was academic.

Figure 1: 2 x 250 MW (t), 210 MW (e) at Rongcheng, China

South Africa and Africa has a unique position in the service delivery sector. Traditional solutions have lagged, and what is required is a leapfrog effort in terms of providing service delivery to the growing population. The new generation SMR is equivalent to that of cellular communications. There is no need for large-scale investments in "wire connected solutions"—this attribute afforded rapid growth in mobile technology acceptance right across continental Africa. The most remote part of Africa has access to mobile cellular technology. Coupled with informed buying, SMR's are poised to make deep penetration into providing service delivery to the growing population of Africa. SMR's can take its seat at the centre of society's needs for electricity, water and waste management. We can further address food security as in aquaponics (fish farming) and hydroponics (vegetable farming) promoting urban or industrial agriculture. Aquaponics and hydroponics are heavily dependent on quality electricity and heat resources; to be continuously available at affordable rates.

CONCLUSION

In conclusion, we present to the Southern African Power Pool the idea of incorporating SMR technology into the menu of generation expansion options; to complement the existing regional generation and transmission systems. The confidence of the new technology emanates from the work done by the Chinese. The design work had commenced in 1992 with a 10 MW pebble-bed high-temperature gas-cooled test reactor (HTR-10) at Tsinghua University's Institute of Nuclear and New Energy Technology (INET). In 2003, the HTR-10 reached its full power operation. The experiments confirmed the passive and inherent safety features of the design. In 2012, the construction of the first demonstration power plant

commenced in Rongcheng, Shandong Province. The reactor started commercial operation in 2019. Figures 1 and 2, extracted from the IAEA Publication [4] presents the candidate power plant.

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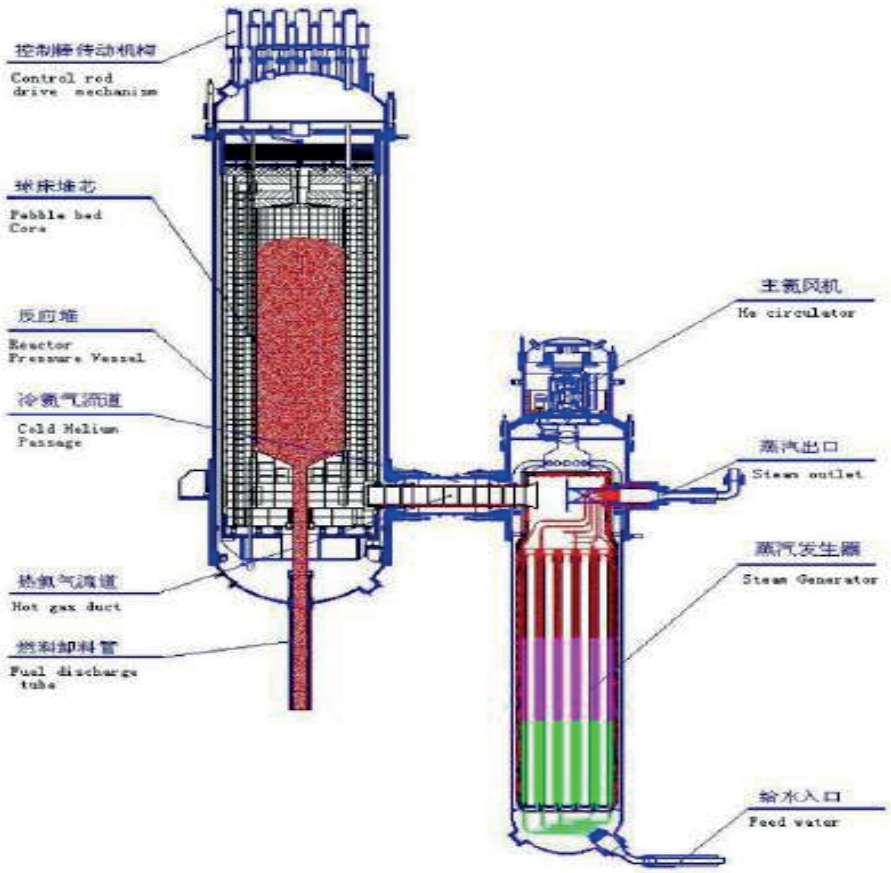

Figure 2: The PBMR HTGR Design Layout

Developing Small Modular Nuclear Reactors For Water Security In Africa

THE CASE STUDY FOR THE WESTERN CAPE OF SOUTH AFRICA

The mighty Atlantic and Indian Oceans cradle continental Africa while rainfall harvested freshwater is conveyed by the mighty rivers such as the Congo and the Nile back into the oceans. The challenge of scarcity of water in Africa is access to these water resources. Large quantities of energy are required for desalination of seawater. Similarly, large pump stations are needed to move the freshwater from the rivers to the customer load centres.

BY | PROF P. NAIDOO (FSAIEE) | PROF S.H. CONNELL (FSAIEE) | D. NICHOLLS (FSAIEE) | A. C. CILLIERS (FSAIEE)

Given the unavailability of transport and delivery pipelines for bulk water transfers from source to load centres, an opportunity exists to employ small modular nuclear reactors as a local energy source to promote desalination of seawater or to pump water from the rivers to the customer load centres.

Small modular reactors have the competitive advantage of being local to the site for application as a secure energy source for water security. The added benefit is waste heat of the reactor; the waste heat promotes the recovery of freshwater from wastewater resources such as from sanitation.

The paper reviews the water security challenges of the Western Cape of South Africa. It proposes both desalination and wastewater recovery strategy using the heat source of a dedicated small modular nuclear reactor of the nominal capacity of tens of megawatts.

The option of pumping freshwater to complement existing water storage capacity exists for water resources located outside of the Western Cape.

INTRODUCTION

Africa's inclusive growth embraces the United Nations Agenda 2030 of Sustainable Development. The demand for affordable, accessible and reliable water supply will increase.

A study by Jury advises that South Africa needs to act with urgency to ensure water security for all [1]. The continent must start to invest in alternative water resources such as municipal wastewater and coastal seawater, as part contribution to long-term water security. In the case of South Africa, the country has a strong national asset of storage dams and comprehensive water catchment plans and strategies.

However, the recent economic hardship of the Greater Cape Region is testimony that sole reliance on rainfall will be inadequate.

UNDERSTANDING THE WATER SECURITY CHALLENGE OF SOUTHERN AFRICA AND THE REGIONS OF SOUTH AFRICA [2]

South and Southern Africa are located between the Atlantic Ocean and the Indian Ocean, with high-pressure zones on the west coast and east coast, respectively. The east coast receives the southward flowing warm Mozambique current, which brings warm water and humid air from the equator; resulting in a damp, warm and wet climate. The west coast is influenced by the Benguela current from the cold Atlantic Ocean which

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Locality	Opportunity	Risk
East Coast of South Africa	Wet and Warm Climate; suitable for large-scale forestry which will promote photosynthesis and support the natural processes of carbon capture and storage.	Flooding Opportunity to develop flood control and dams for fresh water storage and distribution; Mozambique, Swaziland, Lesotho and Eastern South Africa
Eastern Interior of South Africa	Abundance of Rainfall, Frost and Snow; Swaziland and Lesotho are sources for fresh water; both countries are ideally suited for large scale cross border water transfers; Lesotho is currently a large-scale supplier of fresh water to Gauteng South Africa.	
The Greater Cape (Northern, Western, Southern and Eastern)	Naturally, dry and arid conditions prevail across the Greater Cape; North, South, East and West. However, winter rainfall from Atlantic cold fronts compensates for the naturally dry and arid conditions. If the winter rains are disturbed, drought will prevail and the region will experience very dry conditions for long periods; the Greater Cape is ideally suited for large-scale investment in desalination.	

Table 1: Listing of the Fresh Water Opportunities and Risks for South and Southern Africa

brings cold water and dry air from the equator; resulting in a drier and colder climate.

In the interior, we have a strong rainfall gradient from east to west. From Swaziland to Lesotho, the altitude increases and causes the moist air from the Indian Ocean to precipitate, producing the most torrential and most reliable rainfall. As we travel westwards, the total rain decreases, and much of the central and western regions of South Africa is semi-desert with low and variable rainfall. The exception is the Southern and Western Cape, which receives its dosage of rain during the winter months.

The rain comes from cold fronts that emanate from the South Pole. If these cold fronts are disturbed, we will have the same weak and variable rainfall as that of the central and western regions. South Africa has two distinct rainfall seasons; one wet and one dry. The wet season is from November to April and the dry season is from May to October. Summer rainfall is mostly in the form of thunderstorms. Frost is common in winter and snow occurs in the high altitude areas; notably Lesotho and the Drakensberg range and that of the Mountains in Southern and Western Cape. The region experiences frequent droughts. Rainfall distribution is generally uneven. Climate change driven by global warming will intensify the impacts.

Province	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018
Eastern Cape	AN	N	N	BN	N
Western Cape	AN	N	N	BN	N
Kwa Zulu Natal	N	BN	BN	N	N
Free State	N	N	BN	N	N
Gauteng	N	BN	BN	AN	N
North West	N	BN	BN	AN	N
Mpumalanga	AN	BN	BN	AN	N
Limpopo	AN	BN	N	AN	N
Northern Cape	N	N	N	N	N

Table 2: South African Provincial Rainfall for the Period 2013 – 2018 as at 30th July 2018 [3]
AN = Above Normal, N = Normal, BN = Below Normal

A research recommendation from a study conducted by the Department of Environmental Affairs [2] suggests that in terms of SADC trading, more water-intensive products be imported from the countries having a higher water footprint; however, the impact on the trade balance, food security and energy security will require further investigation.

Table 1 lists the freshwater opportunities for South and Southern Africa. Table 2 provides a summary of the rainfall performance over the last five years. South Africa's provincial rainfall trend over the previous five years shows that the country receives at times average rainfall, at times above normal rain and at times below-average precipitation. The pattern is cyclical and, in all probability, it follows the natural global environmental trends for the delivery of rainfall.

MANAGING THE IMBALANCE IN RAINFALL

The classic engineering approach to managing the imbalance in supply is to provide storage. The hydrological and civil engineers have over time-built dams in the rainfall catchment areas. South Africa has delivered, over time, an excellent engineering effort in the planning, design and construction of water storage dams and associated water transfer schemes across the country. For the case of the Western Cape, we note above-average rainfall in the 2013/2104 period, average rainfall in the 2014/2015 and 2015/2016 periods and below-average rainfall in the period 2016/2017. The below-normal rain in 2016/2017 severely stressed the Western Cape economy; implying that the storage capacity is either below present-day requirements and or that demand is exceeding supply.

The cyclical nature of rainfall patterns is not a new phenomenon in South Africa.

In the late sixties, South Africa had experienced severe water shortages in the heart of the mining territory; the golden triangle of Pretoria, Witwatersrand and Vereeniging. The South African administration of the day was very concerned and promoted new legislation for the creation of the Water Research Commission of South Africa. New law led to the Water Research Act No 34 of 1971. The Act deemed research and investigations to be of national importance to generate new knowledge and to forward plan for the water security of the nation. The concern was and remained that water could be a limiting 21st-century constraint to national economic growth and development.

In 2011, South Africa prepared and released a blueprint for guiding policy and investments for South Africa's long-term vision of addressing the triple challenge of poverty, inequality and unemployment. The procedure was aptly titled the National Development Plan of 2030, was adopted by Cabinet in 2012 and in June of 2017, a Vision 2030 Summit endorsed the plan for acceleration on delivery of outputs [4]. Two relevant outcomes of this endorsement pertain to the promotion of public-private partnerships is for new investment opportunities in provincial and local government. We need to discover modern and innovative solutions, plans and initiatives that can fast track the goals as set by the business and investment communities. By 2030, a key goal is for all South Africans to have access to reliable and affordable water services and full water security for national economic activity.

Quoting from the 2016/2017 Annual Report of the Water Research Commission of South Africa [5], "South Africa's water scarcity is now an undisputed fact, and the vulnerability of all, from domestic householders to major industrial players, is now clear.

Water security cannot be on the hope of a return to normal rainfall patterns alone. We have to adapt to the new water availability. There is a greater need to harness alternative water sources. South African communities can no longer depend solely on expensive dams and water pipelines to supply them with their water needs."

TOWARDS HARNESSING ALTERNATIVE WATER RESOURCES

Windhoek of Namibia receives very little annual rainfall. In 1964, the Council for Scientific and Industrial Research of South Africa began experimentation with a reclamation pilot plant in Windhoek. The plant started in 1969 and to date, continues to provide high-quality potable water from municipal wastewater. A study conducted by the California Institute of Technology [6] showed good acceptance of the wastewater to clean water engineered solution.

In 2001, the City of Windhoek commissioned the Gorengab Water Reclamation Plant of 21,000 m^3/d capacity. The raw water used is that of municipal wastewater. The municipal sewage goes into maturation ponds before treatment in an advanced multi-barrier system. The multi-barrier system employs several barriers for all crucial contaminants and thus guarantees outstanding drinking water quality. Since start-up, the plant has complied with all the relevant standards.

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In 2006, the Water Research Commission published a Desalination Guide for South African Municipal Engineers [7]. The availability of seawater for coastal cities and towns, and given that membrane desalination technology is becoming more affordable, makes desalination a viable option to supply freshwater for domestic consumption.

South Africa's saline water resources consist of seawater and groundwater. South Africa has a long coastline comprised of the east coast, the south coast and the west coast. The east coast water is in the temperature range of 21 – 25 °C.

The west coast water is in the temperature range of 9 -14 °C. The low water temperature of the west coast will demand higher operating pressures and will, in general, be more expensive than that for plants on the east coast. In general, thermal distillation systems and membrane-based reverse osmosis systems are technologies for desalination.

THERMAL DISTILLATION OF SEA WATER FOR DIRECT INFEED INTO THE CAPE TOWN MUNICIPAL WATER SUPPLY SYSTEM

The Koeberg Nuclear Power Station is situated outside Cape Town on the West Coast of South Africa. The power station operates two pressurised water reactors of 965 MW generating capacity. The pressurised water reactors operate at a temperature of 300 ˚C and 150 bars. The high pressure in the primary closed-loop prevents the water from boiling and converting to steam. In a secondary circuit consisting of a steam generator, steam is produced to drive one high-pressure turbine and three low-pressure turbines which in turn drive the generator. The steam is recycled; it flows into the condenser, cooled back to liquid water and is returned to the steam generator. The third cooling circuit is the tertiary loop which uses seawater in the condensers.

Seawater is taken in at the rate of 80 tons per second (80 000 litres per second) to cool the steam in the two condensers, 40 tons per second (40 000 litres per second) for each reactor. Once the cooling work is complete, the water is returned to the sea.

The average incoming water temperature is 15˚C, and the return water is at 22˚C; an uplift of 7˚C. Each of the three water circuits operates independently of each other and has no contact or opportunity to mix.

The large-scale intake of seawater and that of elevating its temperature during the cooling of the condensate has value in terms of large-scale desalination. Given the availability of high quantities of nuclear-powered energy, large-scale desalination will be practical and economical at Koeberg.

DESALINATION AND WASTE WATER RECLAMATION

Membrane-based reverse osmosis systems are proving viable, and many investments have shown success.

In 2015, the Water Research Commission commissioned a study into the cost and operation of Southern African Desalination and Water Reuse Plants [8]. The study published in three volumes consists of:

- Volume I: Overview of Desalination and Water Reuse;
- Volume II: Status of Desalination and Water Reuse in South Africa;
- Volume III: Best Practices on Cost and Operational Aspects of Desalination and Water Reuse.

The plants selected in their study are located on either the South Coast or West Coast of South/Southern Africa, as per table 3.

The investigation aimed to capture real-time operational and maintenance data. Together with the literature review, the reports provide a context of state of the art concerning the technology as employed at the selected plants. Volume 3 captures the case study learnings and tables a set of recommendations for further consideration.

A summary of the lessons learned is as follows:

- Promote planning of water processing plants to anticipated demand.
- Promote an integrated model of

NO.	PLANT	TYPE OF PLANT
1	Mossel Bay 15 Ml/d SWRO	Desalination- direct potable
2	Sedgefield 1,5 Ml/d SWRO	Desalination – direct potable
3	Albany Coast 1,8 Ml/d SWRO	Desalination – direct potable
4	Beaufort West 2,1 Ml/d reclamation plant	Reuse – direct potable
5	Windhoek 21 Ml/d Goreangab reclamation plant	Reuse - direct potable
6	George 10 Ml/d UF plant	Reuse – direct potable
7	Mossel Bay 5 Ml/d UF/RO plant	Reuse – direct potable

Table 3: Plants Selected for the WRC Study

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design, operations and maintenance of desalination and reclamation plants.

- Promote public-private partnerships for the development of desalination and reclamation plants
- The relationship between investor, operator and the owner should be on a long-term basis for enhanced sustainability
- Note that operational costs are equally important to that of capital expenditures; cases exist where operational costs have a higher value than capital expenditures.
- Plants once built should not be idle; periodic operations are necessary for the sustainability of the plant health and condition
- UF and RO membranes are designed for continuous operation and have a design life of 5 to 7 years. Frequent starting and stopping of the plants to minimise operating (electricity) costs are not optimal for the membrane life.
- Time of Use tariffs should be explored for cost-effective plant operations
- Staff training and development, including technology transfer, should be an integral part of the operating and maintenance package for desalination and reclamation plants. A culture of continuous learning is required as such water plants are technology-intensive
- Quality control and quality assurance are vital for successful operations of the technology-intensive water plants. These should include a full catchment and water cycle monitoring plan.

The brief overview provides the following direction for the consideration of desalination and reclamation plants in South and Southern Africa.

- Desalination by reverse osmosis technology is best suited for the warmer east coast of South Africa. Typical coastal cities such as Port Elizabeth, Durban, Umhlanga and Richards Bay will make ideal sites for desalination investment.
- Desalination and reclamation plants should be designed for continuous and efficient baseload operation. Given a useful "infinite resource, natural or waste", the plant should be scaled such that a right balance is achieved between operating costs and throughput.
- Reclamation of municipal wastewater is best suited for the coastal cities of the colder west coast of South and Southern Africa. The present locality of such reclamation plants supports this observation. The colder south and west coast of South Africa is not suitable for desalination. These sea waters also experience the 'red tide" effect whereby, at times, the oxygen content of the water drops, which leads to devasting impacts on marine life.
- Cape Town and the Western Cape needs more dams and storage. The Western Cape had above-average annual rainfall before two years of average rainfall. A year of below-normal rain caused severe water shortages. Here the demand exceeded supply. It is clear that demand is on the increase and will continue to increase given the attractiveness of the Western Cape to both local and global citizens.
- Desalination and reclamation are technology-intensive and requires continuous maintenance and condition monitoring. Harnessing alternative water resources is both technology and energy-intensive.

EXPLORE LARGE SCALE CROSS-BORDER WATER TRANSFERS ACROSS SOUTHERN AFRICA AND INTO THE GREATER CAPE REGIONS

The Lesotho highlands waterworks and water transfers to South Africa's Gauteng province refers to the opportunity to develop the transfer system exists. Swaziland and Mozambique have the potential to provide cross border water to the Gauteng economic hub of South Africa; this opportunity is explored. Deeper into Southern Africa and towards the equator; we encounter the primary drainage system of continental Africa; the Congo River. The river has the potential to provide for the freshwater requirements of all of Southern Africa.

The successful cross border water transfers from Lesotho to South Africa has mutual value for both countries. This creates a win-win arrangement. Water can be pumped from one catchment basin to the next; allowing for natural gravity feed from basin to basin and then further supported by additional pumping. The flow of freshwater southwards from the Congo River of Central Africa will spur new growth and development right across Southern Africa; the wildlife, fauna, flora and the tourism industry will gain immensely from the new life created by bulk water flows. Pumping has value for new energy sales for the electricity utilities. This will be new revenues against standing costs; a profitable result.

INTRODUCING SMALL MODULAR REACTORS AS SOURCE OF HEAT FOR WATER SECURITY [9]

SMR development follows specific applications. SMR is a modular design and can incrementally match specific and customised energy requirements such as desalination and wastewater

reclamation. Presently, more than 50 SMR designs under development for different application. Every plan has the opportunity to employ the waste heat for enhancing water security; either by desalination, distillation or wastewater recovery.

The industrial demonstration units, due for commissioning and operation in the period 2019/2021 are in Argentina (CAREM, an integral PWR of capacity 30 MWe), in the People's Republic of China (HTR-PM, a high-temperature gas-cooled reactor of capacity 210 MWe) and the Russian Federation (KLT40s, a floating power unit of capacity 70 MWe). Also, the Russian Federation has already manufactured six RITM-200 reactors (an integral PWR) with four units already installed in the Sibir and Arktika icebreakers, to be in service in 2020.

One particular design that only provides thermal output for district heating and desalination duty is the pool type reactor from China; to be licenced in 2019 for 2021 commercial operation. The district heating reactor (DHR400) has a thermal power output of 400 MWt. There is no electrical power output. The unit operates at low temperature and atmospheric pressure. The technology is mature and is the conventional light water reactor technology. The design has inherent safety features, is simple to operate and maintain and is economically competitive. The motivation for the design emanated from coal-fired heating plants and associated air pollution. The SMR will replace the existing coal heating plants.

DHR400 is a pool-type reactor consisting of a cylinder with an inside diameter of 10 m and an overall height of 26 m. The pool is made of reinforced concrete with an inner layer of 5 mm stainless steel and an outer layer of 10 mm carbon steel. The large water inventory provides the large thermal inertia, which enhances the resistance of the system to transients and accidents of a core meltdown. The 1800 tons of water inside the reactor pool has excellent heat capacity and ensures that the reactor core remains submerged.

The core has 69 fuel assemblies. Each fuel assembly is 2.1 m long. The uranium enrichment is below 5 per cent. The reactor will operate continuously for 150 days per year, with a three-batch refuelling on a 10-month refuelling cycle. Reactivity control during normal operations is by control rods.

PARAMETER	SPECIFICATION	COMMENT
Reactor Type	Pool Type Reactor	Inherently Safe
Coolant/Moderator	Light Water/Light Water	Mature Technology as employed in the large nuclear reactors
Thermal Output MWt	400	Continuous Rating
Electrical Output MWe	0	Customised Application for District Heating and Water Security
Primary Circulation	Forced Circulation	
Core Inlet Pressure (MPa)	0.3	These specifications are similar to that existing at the Koeberg Nuclear Power Station located in the Western Cape. There will be an abundance of local skills for managing, operating and maintaining the new investment in water security.
Core inlet/outlet temperatures (o C)	68/98	
Fuel Type/Assembly Array	UO 2 pellet/ 17 x 17 square	
Number of fuel assemblies	69	
Fuel enrichment (%)	< 5.0	
Fuel burnup (GWd/t)	30	
Fuel cycle (months)	10	
Main reactivity control mechanism	Control Rod Drive Mechanisms	
Design life (years)	60	
Plant footprint (m 2)	40 000	
Pool depth/diameter (m)	26/10	
Seismic design	0.3 g	

Table 4: High Level Technical Parameters of the DHR400 SMR

This type of design is suitable for long periods of constant heating. The continuous supply of heat will ensure a consistent and constant supply of fresh water from either sea or wastewater resources. Table 4 provides the high-level technical parameters of the design.

CONCLUSION

Having secured a safe and constant supply of heat, the next step will be the development of the business case. The inputs can range from sea to wastewater, and output will be a constant supply of fresh water. Given the very long period of stable and secure heat availability (continuous for 60 years plus), the amortisation costs will be meagre and affordable. This approach guarantees water security for the growing population, tourism, agricultural and other associated industries of the Western Cape.

Renewable solar technology can deliver similar heat energy for making freshwater from sea or wastewater resources. Recommend we add the option to the business case study. The work function will be from sunrise to sunset. For after-hours, storage of either heat energy or recovered freshwater will need to be included in the business case-sensitivity study.

Conventional harvesting and storage of rainfall will be the third option on the water security menu. The civil engineered dam will have a similar life span to the SMR. Finally, the importing of bulk freshwater is an option. The business case study can work through the numbers and provide the leadership to the decision-makers and customers of the Western Cape. wn

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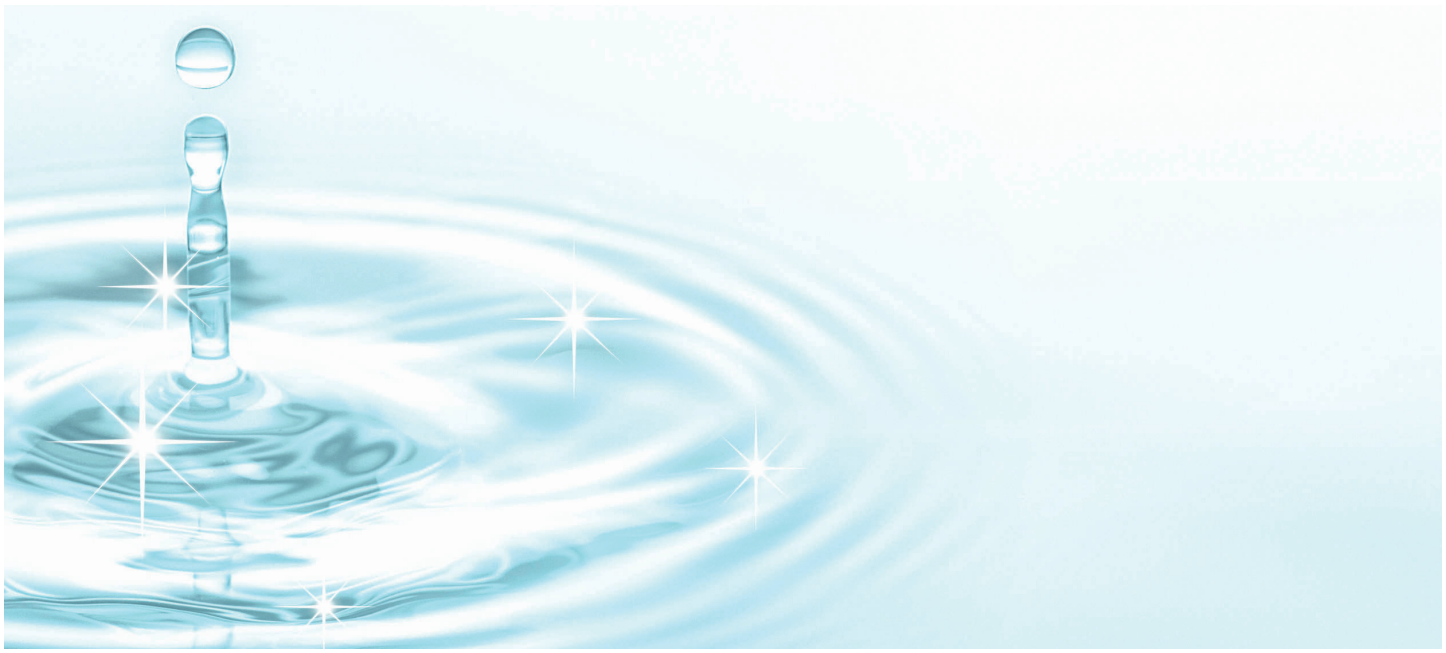

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Quality Standards for South Africa's Carbon Emissions

United Nations Sustainable Development Goals, Agenda 2030, entitled "Transforming our World" has tabled aspirations for urgent action on climate change. COP 24, held in 2018 in Poland, wants greater urgency of effort from all countries in managing carbon emissions as a prime contributor to human activity impact on climate change.

BY | PROF P. NAIDOO (FSAIEE) | K. PULE | N. SUKDEO | S ZUMA

South Africa is historically embedded in thermal coal power generation and liquid fuel transportation of goods; both being primary sources of contributions to carbon emissions, jobs and the economy. Reducing the dependence on coal and liquid fuels will also influence employment and affect the economy. The interdependencies are complex.

The paper presents the status of South Africa's contributions to carbon emissions and the country's aspirations as committed at COP 21. The key performance indicators for the transition period of 2020 to 2050 is considered. The paper concludes with a research proposal for developing strategies and quality standards for managing South Africa's carbon emissions over the next three decades.

INTRODUCTION

South Africa has a diverse nation with a population of 57.7 million (Statistics SA, 2018). South Africa is a significant industrial and economic power and has the largest economy in Southern Africa. It has the well-developed mining, transport, energy, manufacturing, tourism, agriculture, commercial timber and pulp production and service sectors. Various factors influence GHG emissions in SA. Dominant is coal. South Africa has experienced a seven-fold increase in fossil-fuel CO_2 emissions since 1950, with 80-90% of emissions from coal. The National Development Plan provides the foundation for South Africa's vision of economic and socio-economic growth and advancement. It recognises the pivotal role that coal plays as the primary input in energy. It envisages that by

2030 South Africa will have an energy sector that promotes economic growth and development through adequate investment in energy infrastructure.

The plan also envisages that by 2030 South Africa will have an adequate supply of electricity and liquid fuels to ensure that economic activity and welfare are not disrupted and that at least 95% of the population will have access to the grid or off-grid electricity. The plan proposes that gas and other renewable resources like wind, solar and hydroelectricity will be viable alternatives to coal and will supply at least 20 000 MW of the additional 29 000 MW of electricity needed by 2030.

Managing Climate Change is about strengthening resilience and adaptability from hazards and climate-related natural disasters. It is about developing and promoting mechanisms to increase the capacity of productive climate change-related planning and management. Under the United Nations Framework Convention on Climate Change (UNFCCC), the call was to strengthen the global response to the threat of climate change by maintaining a global temperature rise below 2 degrees Celsius above pre-industrial levels; and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. At COP 21, the Paris Agreement, 187 countries adopted the agreement. The Paris Agreement requires all Parties to put forward their best efforts through nationally determined contributions (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties regularly

FEATURE continues from page 45

report on their emissions and their implementation efforts.

South Africa tabled its INDC consisting of three parts. GHG emissions will peak in 2025, plateau for a decade up to 2035 and then decline from 2036, in absolute terms, towards 2050. In 2016, South Africa recorded 518 million tons of CO_2 emissions per year. The peak level of 2025 to 2035 was set at 614 million tons of CO_2 emission per year. The decline from 2036 to 2050 will be aggressive and rapid. For noting, the bulk of South Africa's contribution to emissions emanates from thermal coal power generation and liquid fuel transportation.

Greenhouse gases refer to the sum of seven gases that have direct effects on climate change: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF_3). Tables 1 and 2 presents the air pollution data for Eskom and Sasol, respectively [1, 2].

Both Eskom and Sasol are significant players in air pollution contribution. However, there exist many more contributors to South African GHG emissions. The national challenge is to unpack all the contributors, not just Eskom and Sasol, and to manage with internationally accepted quality standards, the migration to the globally acceptable levels of commitment.

INTERNATIONAL QUALITY STANDARDS

ISO has published more than 22 000 International Standards and related documents that represent globally recognised guidelines and frameworks based on international collaboration and consensus. These standards can provide a solid base on which innovation can thrive and are essential tools to help governments, industry and consumers. They can contribute to the achievement of every one of the Sustainable Development Goals (SDGs). Graph 1 illustrates the number of ISO standards that are directly applicable to each Goal; 105 ISO standards apply to Climate Change (SDG 13).

MEASURE	2017/8	2016/17	2015/16
Relative particulate emissions, kg/MWh sent out2	0.27	0.3	0.36
Carbon dioxide (CO_2), Mt	205.5	211.1	215.6
Sulphur dioxide (SO_2), kt	1 802	1 766	1 699
Nitrous oxide (N_2O), t	2 642	2 782	2 757
Nitrogen oxide (NOx) as NO_2, kt	859	885	893
Particulate emissions, kt	57.13	65.13	78.37

Table 1: Eskom Air Pollution Data

MEASURE	2018	2017	2016
Total greenhouse gas emissions (CO_2 equivalent) kt	67412	67632	69250
Greenhouse gas (GHG) emissions intensity (CO_2 equivalent/ton product)	3.78	3.66	3.68
Nitrogen oxides (NOx) kt	147	152	156
Sulphur oxides (SOx) kt	189	202	223
Particulates (fly ash) kt	10.2	10	9.8

Table 2 : Sasol Air Pollution Data

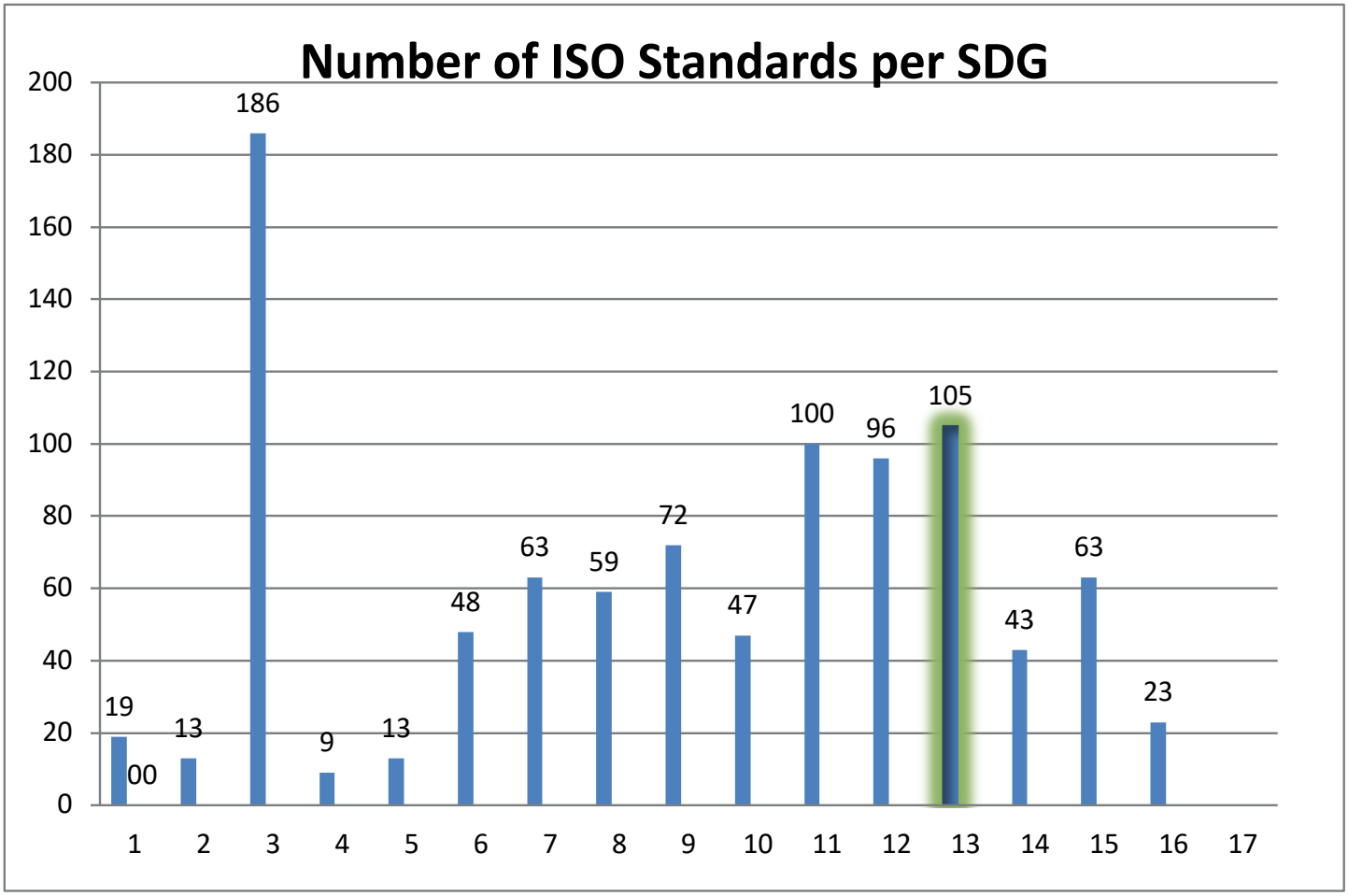
The principles that govern ISO standards are:

- Customer focus – meet customer requirements and strive to exceed their expectations
- Leadership – leadership at all levels to establish unity of purpose and direction and create conditions in which people are engaged
- Engagement of people – competent, empowered and engaged people are essential to enhance the capability to create and deliver value
- Process approach – consistent and predictable results are achieved more effectively and efficiently
- Improvement – successful organisations have an ongoing focus on improvements
- Evidence-based decision making – decisions based on the analysis and evaluation of data and information
- Relationship management – manage their relationships with relevant interested parties

THE FIRST RECOMMENDATION FOR STUDY

The first task of the study in managing South Africa's carbon emissions is to unpack the 105 standards about sustainable development goal, 13, taking urgent action to mitigate climate change.

Each of these standards will have key performance indicators. The data will need to be collected for each of the key performance indicators.



Graph 1: Number of ISO standards per SDG

Measured against the set targets of peak, plateau and decline for the periods 2020 -2025 – 2035 – 2050, will result in a management tool for the country and the sponsor, the United Nations.

RISK AND RISK MANAGEMENT OF CARBON EMISSIONS AND CLIMATE CHANGE

Identification of climate change risk will help in execution and realisation of climate change strategy and intended objectives. The effective determination of the management of climate change key risks starts with an understanding of the procedure and goals.

The principal risks provide insight into potential risks that may affect the realisation of objectives and may indicate the presence of new opportunities. Risk management helps stakeholders identify and prioritise risks.

A SECOND RECOMMENDATION FOR STUDY

A second recommendation is to employ ISO 31000:2018. This standard covers risk management, its principles and guidelines. This primary resource will assist in developing risk management programs.

Risk Management must operate at multiple levels with broad coverage, i.e. they must take into account the reach and range of all the risks faced by the climate change program.

Risk assessment is the part of the risk management process that measures the two attributes that comprise risk, namely, the magnitude of the consequences, and the likelihood that it will occur.

THE THIRD RECOMMENDATION FOR STUDY

Measurement and reporting of climate change performance will assist in alerting all stakeholders to trends towards the achievement of the objectives. The frequency of data collection and reporting of production needs to be agreed on. When measuring and reporting, the following should be considered:

- Availability of data
- Sources of data
- Data integrity

Figure 3 demonstrates the mapping of objectives, KPIs and critical risks. This will reduce the likelihood of the

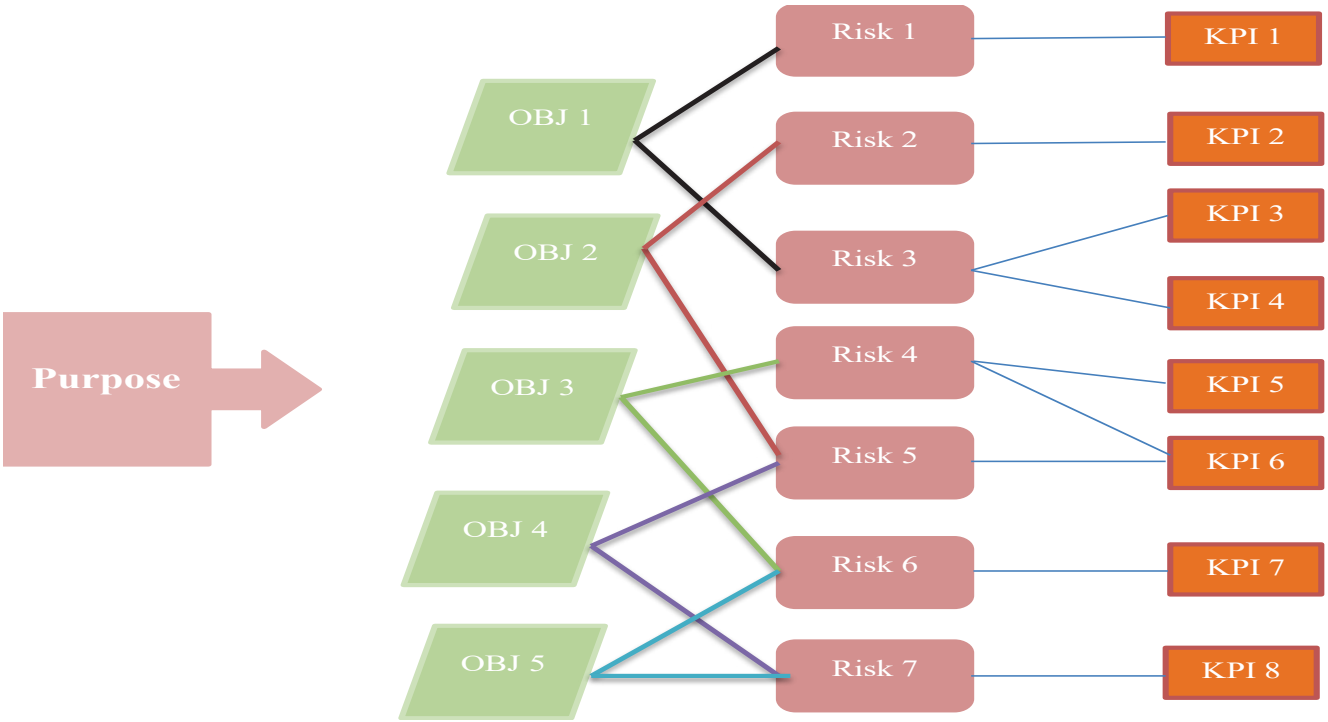


Figure 3: Mapping of Objectives, Risk and Key Performance Indicators

risks occurring and provide insight and information to stakeholders of any risks that could potentially hinder the achievement of the objectives and strategy.

THE FOURTH RECOMMENDATION FOR STUDY

World today is facing high levels of uncertainty and volatility. Governments and organisations must build resilience in their systems and processes for them to prosper in this complex and turbulent world. The extent of uncertainty and volatility is one of the characteristics that will pose substantial challenges for many countries and governments in the achievements of Climate Change objectives.

For the countries to achieve Climate change NDC by 2050, they need to ensure that they are resilient both economically and politically. This ensures that they continue to perform in an uncertain world. Resilience might come down to three things, viz. the ability to adapt to changes, anticipate what might happen next and absorb shocks when they do come along. Resilience requires the ability to make right decisions informed by an understanding of what are the intended objectives and the resources available in assisting in achieving those objectives. This will help in mapping the actions necessary to remain more resilient. Figure 4 illustrates a continuous process for resilience.

THE FIFTH RECOMMENDATION FOR STUDY

Climate change programs operate within a complex landscape, which involves many different stakeholders with diverging objectives. These stakeholders need to be engaged through several engagement channels. A stakeholder is defined as "persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and the ability to influence its outcome, either positively or negatively. Stakeholders are classified in the following categories:

- Authorisers, e.g. Governments
- Enforcers, e.g. regulators
- Influencers, e.g. Civil society
- Partners, industry

Stakeholders will not have the same influence on various climate change programs. Some are in a position to influence the programme so that it is successful; there might be others who feel threatened by it. One needs to consider how to approach those whose interests will be negatively affected to avoid conflict and possible failure of the project.

CONCLUSION

The complexity of climate change requires a multifaceted approach. The proposed quality standard to be developed will need to be internationally acceptable, be standardised in data

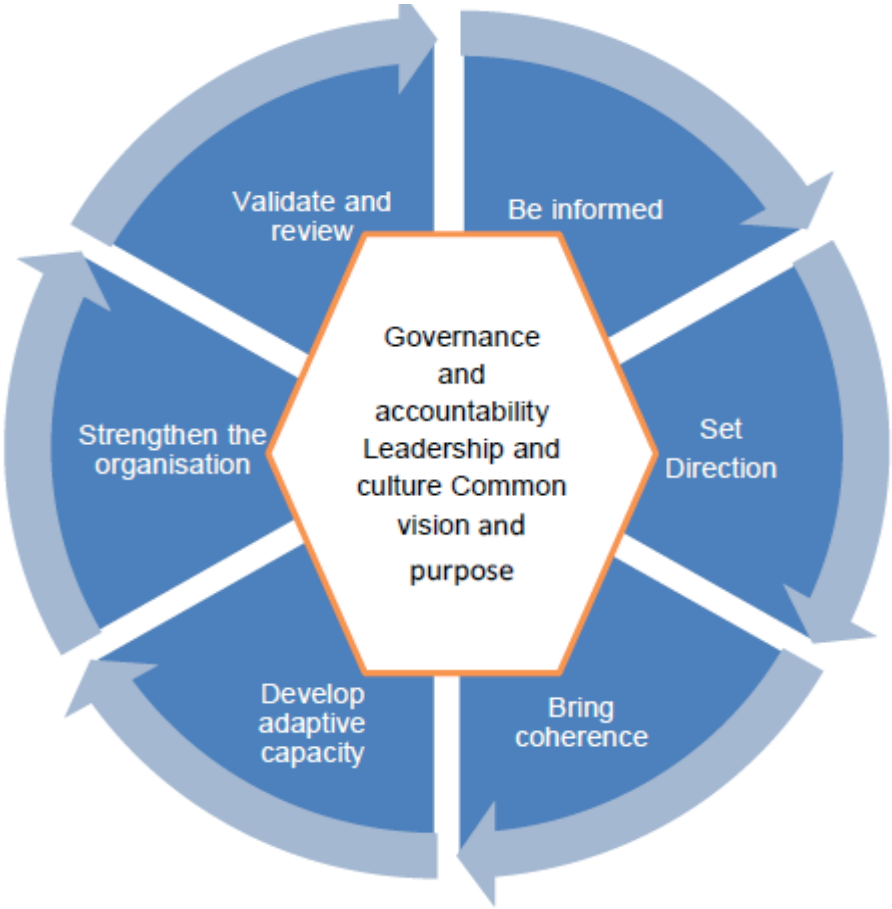
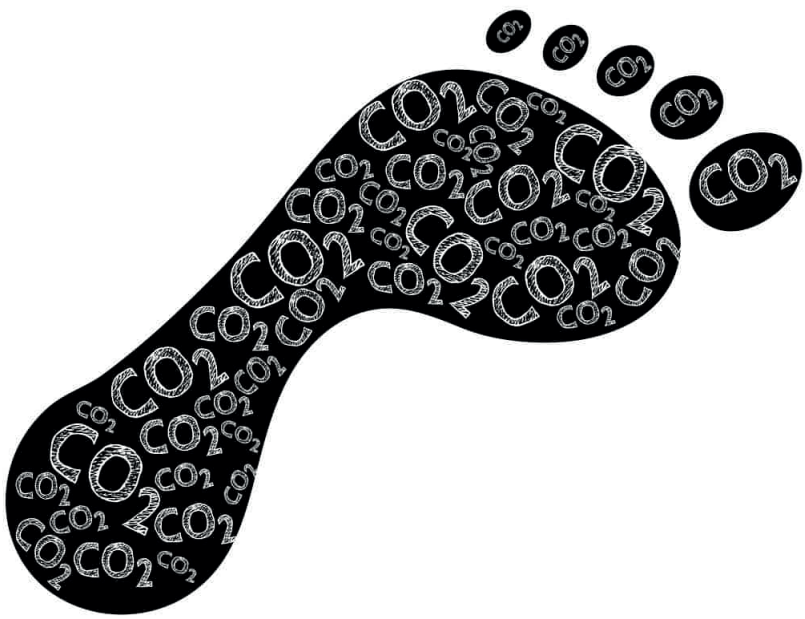


Figure 4: Continuous Modelling Process for Resilience

collection, analysis, measurement and reporting and have measurable impacts on national economic growth, risks and risk management strategies. Climate change is equivalent to poverty; it is man-made, and it is only man with conditioned behavioural practices that could charter a new course for the environment. The exercise of measuring and reporting is to manage GHG emissions downwards from the human activity of industrialisation. wn



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Impact Of Covid-19 On Distribution Network Demand

The Coronavirus has impacted the global economy and has affected the way people live their lives.

After South African President, Cyril Ramaphosa announced the national lockdown on the 26th of March 2020, the SAIEE Load Research Chapter (LRC) hosted an open 'virtual think tank' discussion, to gather views and opinions from industry experts in South Africa. This event took place on the 30th of March 2020.

BY | MONDE SONI, PR ENG
ESKOM SOC (LTD)

The delegates discussed the possible impacts that can be expected in terms of distribution network load as a result of Covid-19 and the national lockdown. The contributors were from distribution utilities (metropolitan municipalities and Eskom), academia and private consultants that are active in load research and power system studies. The video recording of the event is published on the SAIEE TV platform.

The views and predictions from the delegates can be summarised as follows:

- Domestic load shape will be flatter as people can perform activities any time during the day – high diversity.
- Lower living standard measure (LSM) customers will see increased demand.
- Covid-19 will likely have lasting impacts in electricity demand, similar to the significant historical events such as a global recession. The probability of going back to the 'old normal' is minimal.
- Office load, or a portion thereof, will add to the domestic load for wealthy customers, increasing the demand during the day.
- Flat daily demand for domestic customers emanating from the highly diversified load can be expected. This is good for networks that were not operating above 100% thermal rating, but bad for the ones that were already above 100% loading.
- Expect an increase in demand on wealthy customers (due to higher coincidence) – this is contrary to the view expressed above.
- What is experienced from high LSM's will be different from low LSM's.
- Similar customers tend to behave in a similar way, which will lead to high load coincidence at a local level; this will increase the load and can lead to network trips at a local scale (such as mini-subs).
- Voltage rise events can be expected from the non-domestic rooftop PV's as their load is reduced.
- Short term impacts must be studied separately from long term impacts of Covid-19.

The detailed account of the virtual think tank discussion is presented in the section below.

BACKGROUND OF THE DISCUSSION SESSION

In introducing the discussion, the Chairman of the LRC (Monde Soni

from Eskom Distribution) submitted that "there is going to be a very high coincidence factor in terms of the domestic load - almost throughout the different LSM's. The planning and design philosophy for the [network] supply to these loads has always assumed a certain level of diversity, and now that [diversity] may not apply due to customer behaviour changes resulting from the national lockdown.

Introducing rooftop PV's in the picture will reduce diversity even further because the sun shines at the same time in an area/neighbourhood. This can easily lead to local overloads of the Dx network and trips from time to time, especially during peak hours. Distributors like municipalities, etc., may start to see bad technical and reliability performance on their networks".

VIEWS FROM PANELLISTS

Anrich Steyn from GLS Consulting: the concentrated morning peak's amplitude could be flattened due to more flexible schedules since people do not have to concentrate all morning activities simultaneously to be ready by 08h00-09h00. This could flatten the instantaneous peak but could stretch or prolong the peak's duration over a more extended period. As for the evening peak, the same could happen - that the flexibility of having all day to perform activities will lead to a dispersion of load activities, and mitigate the concentration of load activities that people could only perform after work. Residential midday load will, of course, be much higher than usual (suitable for grid-tied PV). Over-generation and accompanying excessive reverse power flow & voltage rise issues that can be introduced by a mismatch in low midday residential load. Peak midday PV production will be mitigated by the higher-than-usual daytime load, which will then provide a sink for the PV power. Load shape will be flatter as people can perform activities at any time during the day – high diversity.

Hilton Baartman from GLS Consulting: the load shapes as we currently know them will change forever. Expect the unknown.

Zoe Lincoln from TNEI: one could also imagine that domestic diversity will be introduced; the elimination of the 8-5 workday commute will mean people wake up at different times, shower at different times etc. This (inverted) curve could be flattened too! But the normal office loads will be moved from CBDs into the suburbs - I think the telecoms providers are feeling this

more than the electricity providers. More diversity due to people not having to follow the 8-5 structure will lead to a flatter load shape.

Lloyd Setlhogo from Eskom RT&D: I have noticed movement from Metros to small towns and villages (people going home for lockdown). The lower LSM will move up slightly; there has already been panic-buying; electricity consumption will be higher than usual at these areas. Lower LSM's will see increased demand.

The Chairman quoted previous events that have affected electrical load demand. These historical events were raised to identify parallels that can be drawn between them and the current Covid-19 pandemic. This will make it possible to predict future scenarios in terms of load demand behaviour.

- 2008 global recession: the global recession slowed down the electrical demand growth in South Africa. To date (more than ten years later) the demand growth has not reached growth rates before 2007.
- 2013/2014 mining contraction: the 2012 Marikana massacre and the mining labour strikes for better salaries led to reduced mining activity which in-turn led to the decline in mining and its related industries' electrical demand. The mining load growth has not recovered to its original trend.
- 2005 energy efficiency drive (replacement of the old incandescent light bulbs with energy-efficient compact fluorescent lamps (CFL)): the general assumption was that once the CFLs reached their end of life, individuals were likely to replace them with incandescent light bulbs as they were readily available at local stores and were cheaper. However, to date, the most common electrical lamps used and sold nationwide are CFL's.

The above-quoted events and initiatives show that human beings tend to adapt to new behaviours quicker. In the long run, one realises that they do not usually go back to the 'old way' of doing things. Covid-19 will likely have lasting impacts on electricity demand, similar to the stated events. The probability of going back to the 'old normal' is minimal.

Anrich Steyn from GLS Consulting: residential load will see an additional commercial component being added to it for the higher LSM customers. This is because these customers will be working from home, and they will most likely use space heating or cooling to ensure comfort. Office load will add to the domestic load for wealthy customers, increasing the demand during the day.

Rabagolo Melesi from Aurecon: we will see a more sustained but flat peak in the higher LSM, and this will help reduce the duck curve. However, for networks that were already running above 100% thermal loading, this situation will present problems. Generally, systems can be overloaded for a short duration without being affected negatively, but if the condition is sustained, then the impact will be seen on the networks.

Marcus Dekenah from Marcus Dekenah Consulting: the impact will be different between lower and higher LSM's. The significant difference between these customer classes is that the higher LSM customers have flexibility and options, while the lower LSM do not have much freedom and flexibility. What is experienced from high LSM's will be different from low LSM's.

Hilton Baartman: the office load will not necessarily be 'copied' into the residential load. The main contributor to the office load is space heating & cooling. However, most homes do not have those specific services.

Marcus Dekenah: Load behaviour similar to a Sunday can be expected. Load factor will likely increase and demand reduced for lower LSM (due to a certain degree of freedom). Overall energy consumption is likely to remain invariant. For higher LSM, the load factor might decrease slightly, and the demand may increase, leading to an increase in overall energy consumption. The higher LSM tends to 'use as they want to' and the cost does not prohibit them. Job losses will lead to more people being at home and thus affecting the power demand in the domestic sector. Expect an increase in demand for wealthy customers (higher coincidence).

Ncedo Mguzulwa (City of Cape Town Metro Municipality): urban networks might not see an impact, generally, as most people will have moved to their original homes.

Chairman: flat curve but with higher volume due to the commercial component that will move to the domestic load. This will strain the network at local mini-subs and perhaps at feeder level for domestic areas. Similar customers tend to behave in the same way, which will increase the load coincidence factor at the local level; this will increase the load and can lead to network trips at a local scale.

CLOSING REMARKS BY ALL PANELLISTS

Marcus Dekenah: I can predict that the demand will come down by 10% for lower LSM.

Anrich Steyn: running the transformer

continuously at a high load might cause problems for Distribution networks.

Hilton Baartman: the networks that were already running at higher thermal loading might be more compromised as the load increases at local networks. This will lead to nuisance tripping that Dx will have to deal with from time to time.

Ncedo Mguzulwa: most of the City transformers are lightly loaded (50-60%), and thus, there should be nothing to worry about. However, for the networks that were already running on thin spare capacity, there might be issues.

Tsolane (GLS): there will be long term impacts as more people will embrace the ideas of working remotely from home, from now going to the future. The new normal starts now.

Ted Isengingo: the idea is that lives will change, the way of working will change, the method of doing business will change forever, and the discussion must expand to include the bigger picture in terms of these changes.

Other issues stated by Chairman: Load reduction from malls is inevitable, as non-essential shops close while rooftop PV's continue generating at their full capacity. This will result in voltage rise at local networks. PV inverters might trip on overvoltage due to this.

CLOSING OF THE DISCUSSION

The Chairman concluded that the inputs provided are to be considered as possible scenarios by distribution utilities. The approach to cater for these is to interrogate each situation and have a plan/solution to mitigate the adverse effects—a 'what if' approach must be followed.

REMARKS AND CONCLUSION

The impacts of Covid-19 on distribution network loads are wide-ranging. This is evident from the range of opinions shared by experts above. There is high uncertainty.

In the short term, the load is expected to rise in the domestic sector and will decrease in the non-domestic area due to the national lockdown. The lower LSM load will increase due to the lockdown as more people are at home, and thermal issues that lead to network tripping can be expected. As the lockdown is eased, these networks will start to experience relief in terms of thermal loading.

In the long term, the domestic load profiles will need to be revised to incorporate a part of the 'new normal' of working from home. This is expected to be the way of life for professions that can work remotely. When the new profiles are available, they can be used to assess the current network performance and will be used to plan and design new networks. The new after diversity maximum demand (ADMD), load shapes and the load coincidence factors need to be established.

To avoid the eminent voltage rise that will result from low electricity consumption in non-domestic sectors, the rooftop PV generation must be reduced in proportion to the load reduction.

With the benefit of learning from previous major events, the long term future (greater than ten years) can be expected to bring a lower load growth. Covid-19 is a global phenomenon, and thus a similar trend to the worldwide recession of 2008 can be expected. This means that the load is likely to decline at a large scale. However, on a local level, effects are expected to be different, mainly because of working from home. The slow recovery of the economy will lead to reduced industrial load growth and the possibility of load decline. This can be learnt from the previous global economic recession. wn

2019 Data on Nuclear Power Plants Operating Experience

In June 2020, the International Atomic Energy Agency (IAEA) released its annual nuclear power status data for 2019 collected by the Power Reactor Information System (PRIS), the world's most comprehensive database on nuclear power. PRIS, developed and maintained by the IAEA for over five decades, contains authoritative historical and current quantitative information on nuclear power reactors in operation and under construction or in decommissioning phase.

BY I MARTA M. GOSPODARCZYK, IAEA DEPARTMENT OF NUCLEAR ENERGY
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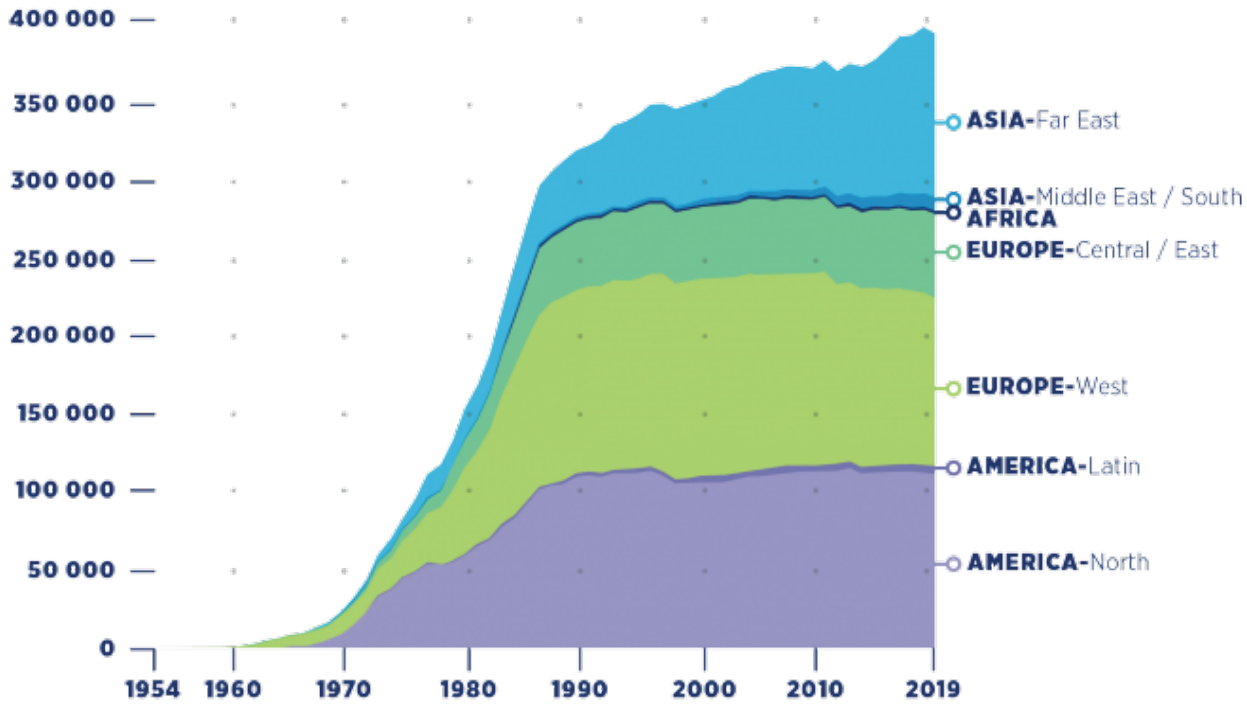
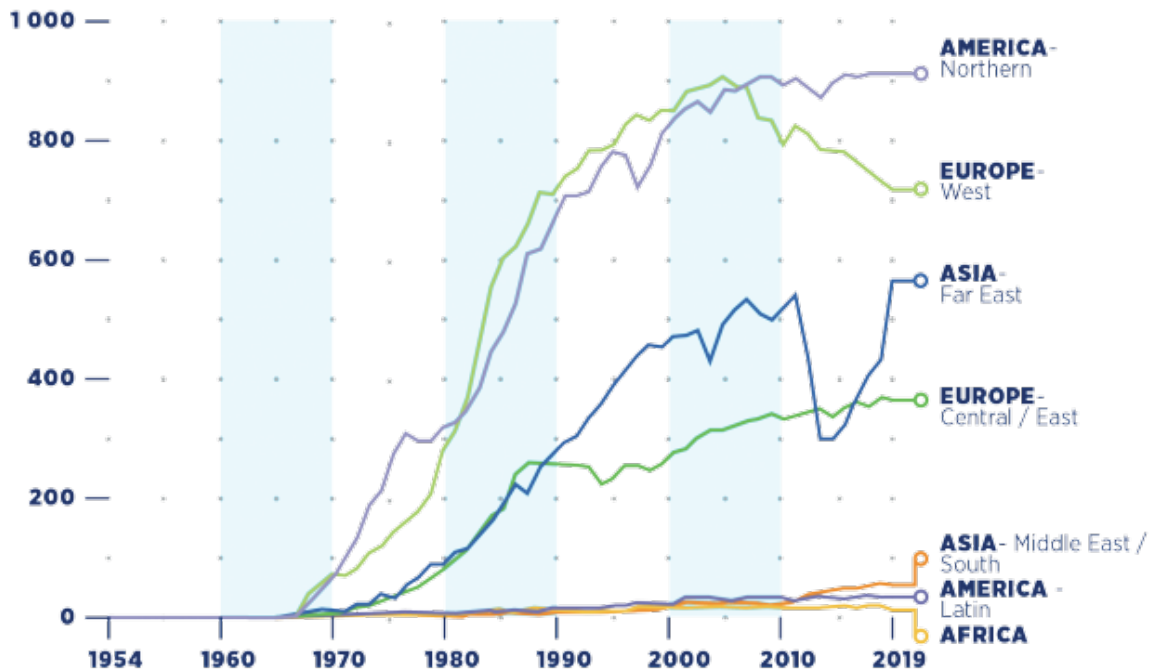
At the end of December 2019, the global operating nuclear power capacity was 392.1 GW(e), comprising 443 operational nuclear power reactors in 30 countries. Overall, nuclear power capacity since 2011 has shown a gradual growth trend, including some 23.2 GW(e) of new capacity added by the connection of new units to the grid or upgrades to existing reactors.

In 2019, though, total global capacity decreased by some 4.5 GW(e) compared with 2018, a figure that reflects Japan's decision to permanently shut down five reactors that had not generated electricity since 2011. At the end of 2019, over 57.4 GW(e) of capacity (54 reactors) was under construction in 19 countries, including four that are building their first nuclear reactor. Near and long-term capacity growth prospects are centred in Asia, which at the end of



Regional Nuclear Power Capacity over time - (MW(e))



Regional Electricity Production over time - (TWh)

2019 reported some 36.5 GW(e) of nuclear power capacity (35 reactors) under construction.

Throughout 2019, nuclear power supplied 2586.2 TWh[1] of emission-free, low-carbon baseload electricity. That accounted for about 10% of total global electricity generation and nearly a third of the world's low-carbon electricity production. Nuclear generation has continuously grown over the past years, expanding by more than 9% since 2012.

CAPACITY ADDED AND UNITS CONNECTED TO THE GRID

In 2019, six new pressurized water reactors (PWR) were connected to the grid, resulting in an additional 5174 MW(e) of nuclear power capacity. Over 77% of this new capacity was added in Asia and included two reactor units in China at Taishan-2 (1660 MW(e)) and Yangjiang-6 (1000 MW(e)), and one reactor unit in the South Korea at Shin-Kori-4 (1340 MW(e)).

In addition, three nuclear power reactor units with a total capacity of 1174 MW(e) were connected to grid in Russia, including Novovoronezh 2-2 (1114 MW(e)) and the world's first commercial floating nuclear power plant 'Akademik Lomonosov' which comprises two units of 30MW(e) each.

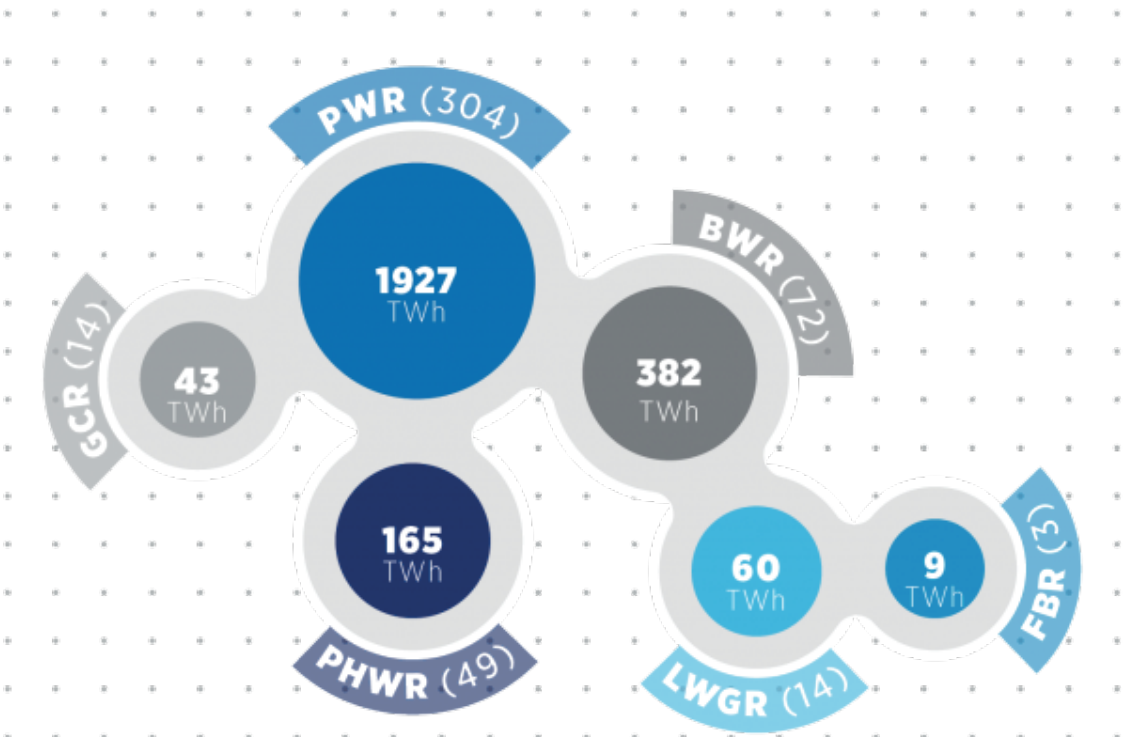
NEW BUILD CONSTRUCTION

As of 31 December 2019, 54 reactors were under construction in 19 countries with a total of capacity of 57441 MW(e). Installed nuclear power capacity under construction has largely remained steady in recent years, except for continuous growth in Asia, where a total of 55067 MW(e) operational capacity (61 reactors) has been connected to the grid since 2005. In 2019, the construction of five PWR reactors began, with two in China (Zhangzhou-1 (1126 MW(e)) and Taipingling-1 (1116 MW(e)) and one each in Iran (Bushehr-2 (974 MW(e)), Russia (Kursk 2-2 (1175 MW(e)) and the United Kingdom (Hinkley Point C-2 (1630 MW(e)).

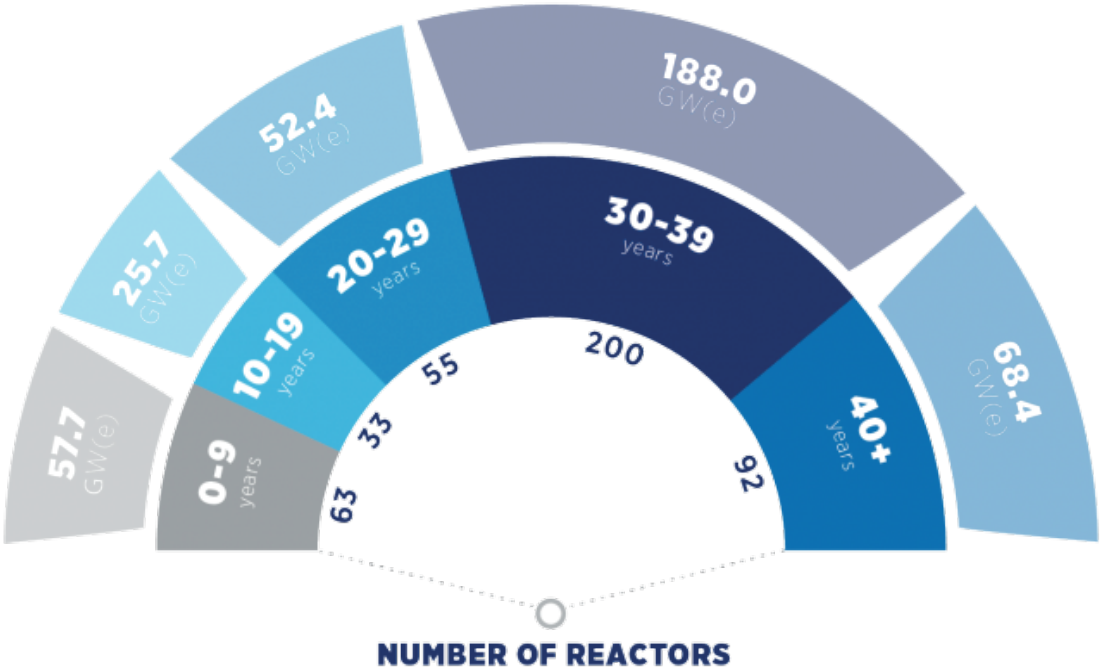
CAPACITY REMOVED AND PERMANENT SHUTDOWNS

Thirteen reactors with a total capacity of 10196 MW(e) were permanently shut down globally. Some 47% of the capacity reduction resulting from permanent shutdowns came from five reactors in Japan that had been idle since 2011:

- Genkai-2 (529 MW(e)),
- Fukushima-Daini-1 (1067 MW(e)),
- Fukushima-Daini-2 (1067 MW(e)),



Electricity supplied by type of Reactors



Reactors in operation and capacity by age.

- Fukushima-Daini-3 (1067 MW(e)) and;
- Fukushima-Daini-4 (1067 MW(e)).

Other permanently shut down reactors in 2019 include:

- Chinshan-2 (604 MW(e)) in Taiwan, China;
- Wolsong-1 (661 MW(e)) in the Republic of Korea;
- Philippsburg-2 (1402 MW(e)) in Germany;
- Ringhals-2 (852 MW(e)) in Sweden;
- Muehleberg (373 MW(e)) in Switzerland;
- Bilibino-1 (11 MW(e)) in Russia;
- Pilgrim-1 (677 MW(e) in Russia; and
- Three Mile Island-1 (819 MW(e)) in the United States of America.

OPERATIONAL REACTOR TYPES

Some 89.2% of the operational nuclear power capacity was comprised of light water moderated and cooled reactor types; 6.1% were heavy water moderated and cooled reactor types; 2.4% were light water cooled and graphite moderated reactor types, while the remaining 2.0% were gas cooled reactor types. Three reactors were liquid metal cooled fast reactors.

NON-ELECTRIC APPLICATIONS

In 2019, 71 nuclear power reactors in 11 countries utilized 2146.7 gigawatt-hours (GWh) of electrical equivalent heat to support non-electric applications of nuclear energy such as for district heating, process heat supply or desalination purposes. About 88% of the heat was supplied by 57 reactors in Europe and 12% by 14 reactors in Asia. Further, 10 reactors supported desalination (using 48.0 GWh), 56 reactors supported district heating (1870.6 GWh) and 32 reactors supported industrial heat applications (1248.0 GWh).

OPERATIONAL LIFETIME

At the end of the 2019, the worldwide cumulative reactor operating experience amounted to over 18,329 reactor years of experience, with a total capacity of 474.2 GW(e) and 629 reactors across 33 countries.

Of these reactors, 186 reactors with total capacity of 82.1 GW(e) are permanently shut down. 256.3 GW(e) of net capacity, representing more than 65% of power reactors, had been in operation for over 30 years. Of this, reactors in service for over 40 years accounted for 17% of global capacity, while 0.5% have been operating for over 50 years.

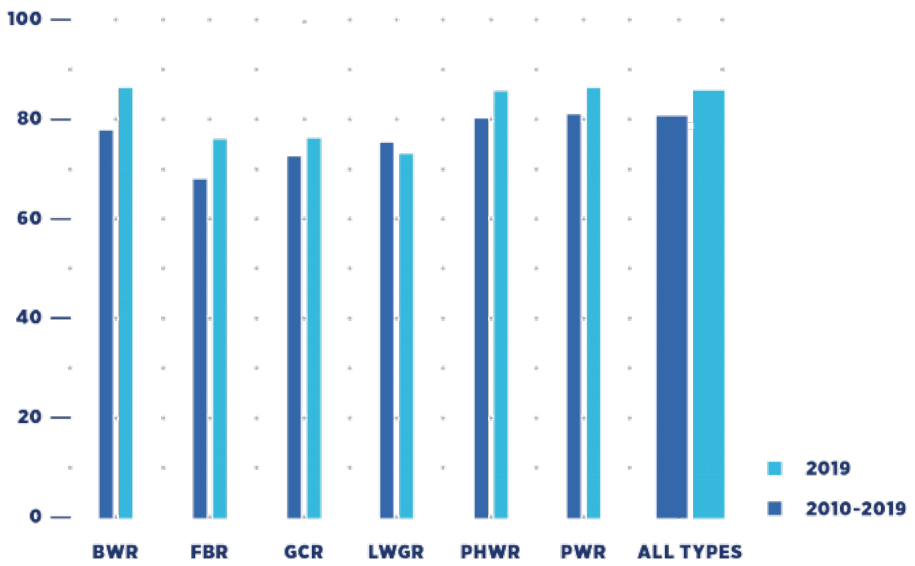
These reactors, all connected to grid in 1969, include two reactors in India (Tarapur-1, Tarapur-2), one reactor in Switzerland (Beznau-1) and two reactors in the United States (Nine Mile Point-1 and Ginna).

Long term operation and ageing management programmes are being implemented for an increasing number of nuclear power reactors globally to ensure continued safe and sustainable operations.

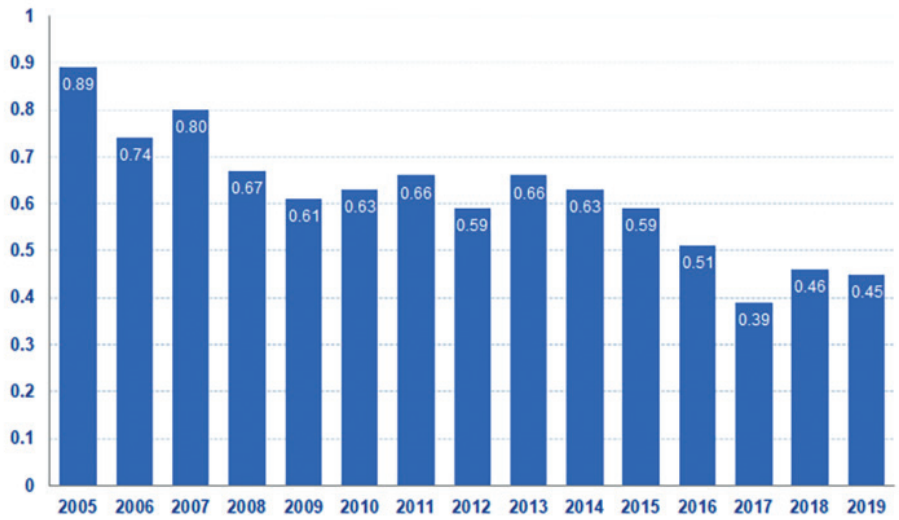
UNIT PERFORMANCE

Even as the nuclear power fleet ages, operational nuclear power plants continue to demonstrate high levels of overall reliability and performance. The Load Factor, also referred to as the Capacity Factor, reflects the actual energy utilization of a reactor unit compared to its reference power output; a high load or capacity factor indicates good operational performance. In 2019, the global median capacity factor was 85.9 %, in line with the load factor in recent years. Another indicator measuring the performance of nuclear reactors is the Energy Availability Factor (EAF), which refers to the ratio of energy that the available capacity could have produced during a specific period of time to the energy that the reference unit power (RUP) could have produced. In 2019, the weighted average EAF was just 77%, where half of nuclear reactors also operated with an EAF above 87%.

The reliability and safety of nuclear power reactors have continued to improve over time. The figures below demonstrate a gradual reduction of the number of unplanned manual and automatic scrams (US7) or shutdowns per 7000 hours (approximately one year) of operation per unit since 2005. The reduction in the number of unplanned scrams indicator is attributed to continued successful plant operations and maintenance management. wn



Load Factor by Reactor Type - Median Load Factor (%)



Unplanned Total Scrams (US7) per 7000 hour critical, per unit

1. *Nuclear generation related statistics for 2019 do not include data from seven German reactor units, as information for these units was not submited by the time of publication.*

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SAIEE CALENDAR

JULY 2020

2	**Power & Energy Section Monthly Meeting** "Opportunities in the energy storage space"
	AM Series - Webinar ISO55k: "Project Portfolio Optimisation" - B Neijens
6	**SAIEE KZN Centre Webinar:** "Explanation Of Conductor Current Rating"
7	**SAIEE Nuclear Chapter Launch:** "Implications of the 2.5GW Nuclear IRP2019"
9	**SAIEE Training Academy - Online CPD Course:** SANS 10142-1. Edition 3 2019 - Day 1
	Power & Energy Section: "Global Electric Power Sector: Engaging with Environmental Issues"
10	**SAIEE Training Academy - Online CPD Course:** SANS 10142-1. Edition 3 2019 - Day 2
15	**SAIEE Training Academy - Online CPD Course:** Fundamentals of Practical Lighting Design - Day 1
16	**SAIEE Training Academy - Online CPD Course:** Fundamentals of Practical Lighting Design - Day 2
15	**Power & Energy Section - Webinar** "Electric vehicles"
21	**Load Research Chapter** "Electrification planning case studies and tools"
	SAIEE Training Academy - Online CPD Course: Financial Evaluation of Projects - Day 1
22	**Power & Energy Section - Webinar:** "Energy Efficiency in Smart Buildings Through IoT Sensor Integration"
23	**WATTNOW ST-TALK - Power Engineering**
24	**SAIEE Training Academy - Online CPD Course:** Financial Evaluation of Projects - Day 2

To organize a webinar on the SAIEE Platform, please complete the **Webinar Booking form**.

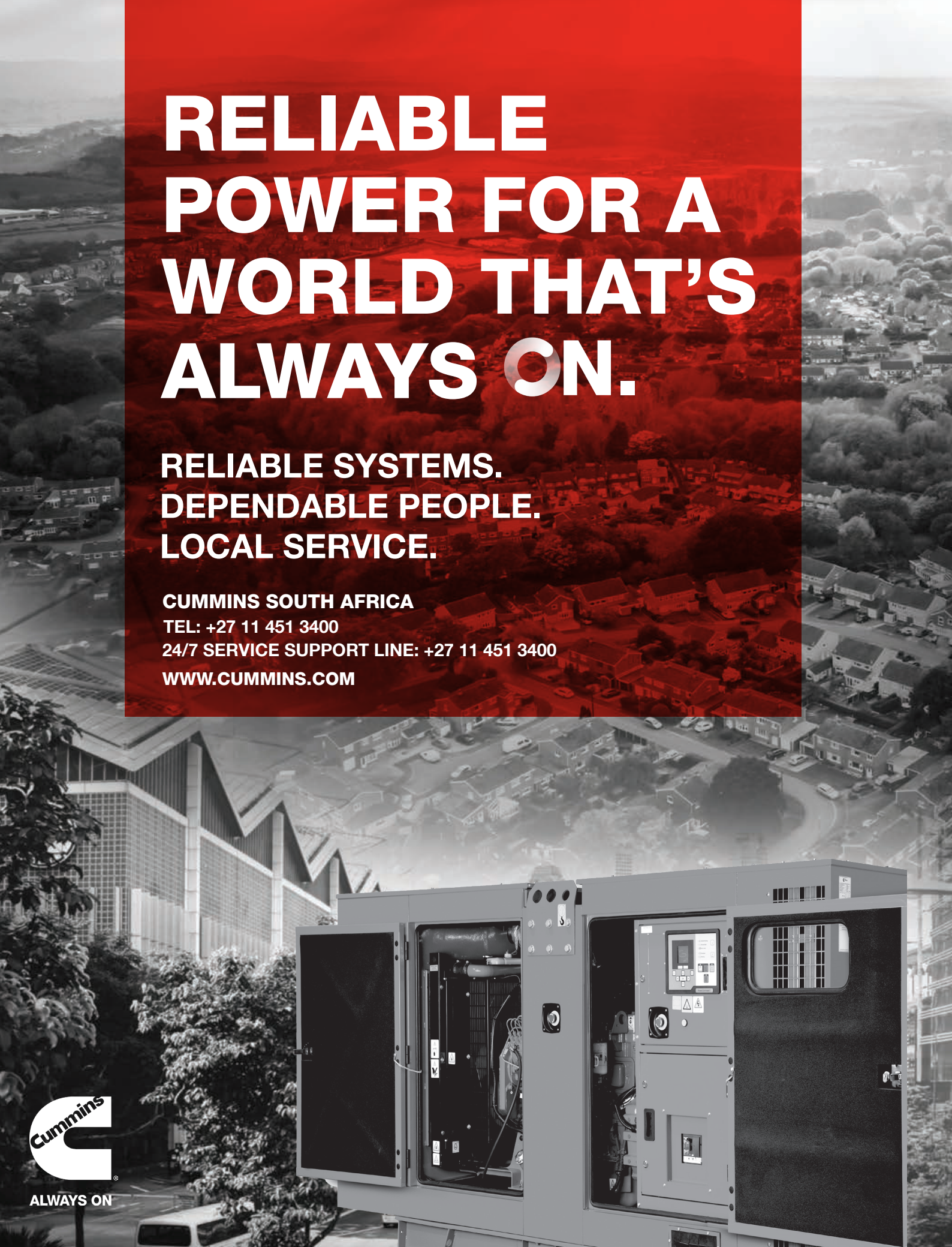
JULY 2020 (CONT)

27	**SAIEE Training Academy - Online CPD Course:** Financial Evaluation of Projects - Day 3
28	**SAIEE Training Academy - Online CPD Course:** Financial Evaluation of Projects - Day 4
29	**SAIEE Training Academy - Online CPD Course:** Power Systems Protection - Day 1
30	Centre Chairs Meeting
	SAIEE Training Academy - Online CPD Course: Power Systems Protection - Day 2
31	**SAIEE Training Academy - Online CPD Course:** Power Systems Protection - Day 3
	Load Research Chapter - Webinar "National & Regional electricity planning models"

AUGUST 2020

5	**SAIEE Women in Engineering - Webinar** "Celebrating Women"
12	**SAIEE Training Academy - Online CPD Course:** Fundamentals of Power Distribution - Day 1
13	**Power & Energy Section - Webinar:** "Role of the Smart Grid in Facilitating the Integration of Renewables"
	SAIEE Training Academy - Online CPD Course: Fundamentals of Power Distribution - Day 2
20	**WATTNOW ST-TALK - Communications**
27	**Power & Energy Section Webinar:** "Lightning Protection, Insulation Coordination for HV Power Lines"
	SAIEE Training Academy - Online CPD Course: HV Testing and Measurement - Day 1
28	**SAIEE Training Academy - Online CPD Course:** HV Testing and Measurement - Day 2

Section & Chapter, Centre Webinars wattnow Webinars SAIEE Academy Online Training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