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SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | JULY 2019

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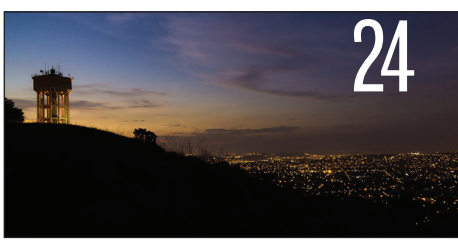
# CONTENTS

## FEATURES




## REGULARS








SAIEE @saiee

# wattnow

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While we are in the throes of winter in South Africa, we have not experienced winter in Johannesburg. With sweltering temperatures, equivalent to the UK's summer, we are gearing up for, in my opinion, a scorching summer. Hot summers bring with it the over-use of water, which is a scarce commodity in our current climate, and we should take heed of what the professionals predict - in doing our bit to save water.

Our first feature article, written by Pascal Motsoasele focuses on improving reservoir structural health monitoring. Our South African Water Utility, Rand Water has over R6.5 billion worth of investment in reservoirs. It is, therefore, imperative that they invest in asset health monitoring systems. Read the story on page 24.

Our second feature article takes a different approach and focuses on the water scarcity in South Africa, which is currently overexploiting its renewable water resources. This report presents a national-level forecast for water supply and withdrawals until 2035. Find it on page 32.

In our "Reader Interest" section, page 48, you will find an article written by Dudley Basson on the Railways of London. He takes a historical look at where it all started, and shares with us, especially our online readers, various links and videos to see these intricate railway lines for yourself.

The SAIEE is gearing up for its National Conference in November 2019. I'm part of the marketing committee and my gosh - this conference promises to be a once-in-a-lifetime-experience. We are incorporating SMME's to showcase their engineering goods, and we have sponsorship packages worth R10 000 for corporates to sponsor these SMME's.
Visit www.saiee-conference.co.za for more information - or to book your seat.

Herewith the July issue, enjoy the read!

Minx

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

SAIEE

# 1ST SAIEE NATIONAL CONFERENCE 2019

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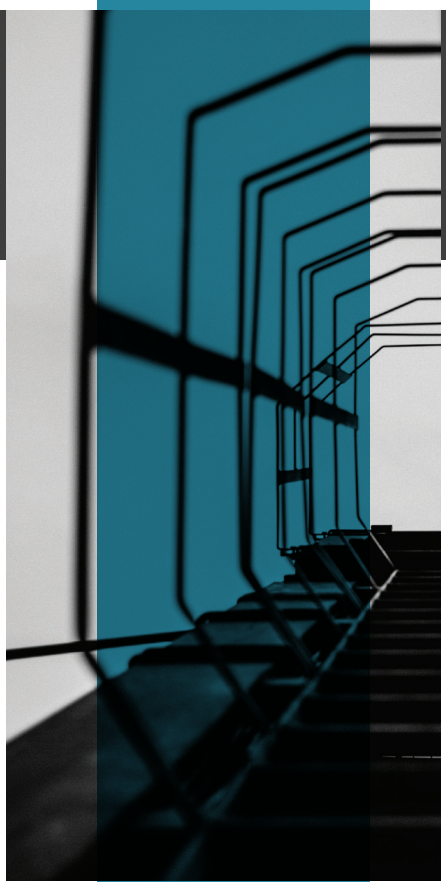

South African Institute of Electrical Engineers (SAIEE) are hosting the **1st SAIEE National Conference 2019** as a **future-thinking gathering** of the electrical and electronic engineering fraternity with a vision of **Engineering an Africa for the Future.** The Conference will **facilitate future-thinking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

## PROGRAMME OVERVIEW

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

**TRACK 1:** BUILD
*Building a Smart Future*

**TRACK 2:** POWER-UP
*Powering a Future Africa*

**TRACK 3:** AUTOMATE
*Driving a Future Africa though Automation*

**TRACK 4:** CONNECT
*Connectivity and Communication for a Future Africa*

**TRACK 5:** EMPOWER
*Capacity Development for a Future Africa*

**TRACK 6:** CHANGE
*Celebrating Africa's Change Makers*

## EARLY REGISTRATION CLOSES
## 31 JULY 2019

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# Do We Need 5G Cellular Technology to Service our Unserved Communities?

**GEORGE DEBBO**
**2019 SAIEE PRESIDENT**

A few weeks back, I participated in an IEEE ComSoc Summit on 5G technology. I gave a presentation on the use of 5G technology as an enabler for economic and social inclusivity, by showing some use case scenarios within various vertical industries that can, if correctly implemented, drive economic growth in diverse, disadvantaged communities.

I also shared some use cases in the health sector that could benefit communities that do not have access to physical health care resources. However, during the discussion and debate sessions that followed, I made the point that the reason why we still do not have a high level of broadband penetration in South Africa is not due to the lack of an available technology, but rather, due to the lack of the necessary enabling policies at a Government and Regulatory level. I indicated that we do not need 5G technology to service those areas of our community that currently do not have access to broadband connectivity. We already have readily available technologies like LTE that can serve this function. What we need instead is a political will to service these areas. I was taken to task by several delegates who felt that by making such a statement I was depriving and discriminating our less fortunate communities, especially within the rural areas, from gaining access to the latest technology and capabilities.

Let me elaborate further on my argument: The next generation of cellular technology, today referred to as 5G (fifth generation), has the purpose of significantly increasing connectivity rates (by 100-fold), considerably increasing the capacity to connect devices, driven by the concept of the Internet of Things, and to reduce latency. All these performance increases are meant to accommodate allied technology developments in artificial intelligence, virtual and augmented reality as well the growth of autonomous vehicles.

At a physical level, one of the fundamental components of 5G technology has been the development of a new radio which extends the use of frequency spectrum into the 6 to 42 GHz range, which we refer to as the mmWave range (also known as the millimetre band). Up until now, this range of frequencies has been primarily used to provide the point-to-point radio links used for transmission between network nodes as well as backhaul between access nodes and the core network. It has now been chosen to provide access connectivity because of the high channel bandwidth that is available in this spectrum. There is a disadvantage in that coverage is limited because of the higher frequencies. Therefore, 5G is not an economical technology for covering rural areas and hence the reason why I made the point that current technologies like LTE


would be much better suited for providing broadband connectivity in unserved rural areas.

## BUT WHAT ABOUT NOT HAVING THE POLITICAL WILL?

In 2013 the Department of Communications, under the leadership of the then Minister Yunus Carrim, released Government's Broadband Policy called SA Connect. The policy set an ambitious but achievable target of delivering widespread broadband access to 90% of the country's population by 2020 and 100% by 2030. Six year's later we are nowhere close on being able to achieve the first target, which is now less than a year away, and the reason being that Government has failed to provide the necessary enabling policy to drive and support achieving the target set down by SA Connect.

The following are the main policy failures:

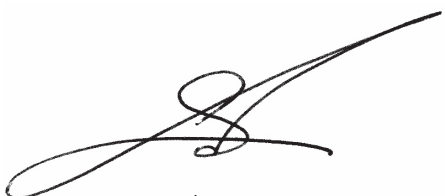
- Government's failure to complete the analogue to digital TV migration. One of the benefits to be derived from this migration is the release of the frequency spectrum in the 700 and 800MHz band, often referred to as the "Digital Dividend". This lower frequency spectrum will allow more comprehensive cellular coverage to be achieved and hence is ideally suited for use in rural environments.
- Government's proposal to introduce a Wireless Open Access Network (WOAN) which would effectively monopolise the provision of wholesale network services under one entity, and from which all service providers would need to purchase capacity. This entity would remove competition at the network infrastructure level and be vigorously opposed by industry players. One major issue that transpired when this concept was being debated was that Government stopped the process of allocating additional frequency spectrum to existing network operators. This forced them to have to re-farm the frequency spectrum from the existing allocation to deploy LTE technology, as well as forcing them to densify their networks by adding additional smaller cellular sites to provide additional capacity. The latter resulted in their deployment costs for their networks increasing significantly. In fact, at one stage, Government was even suggesting that existing frequency spectrum allocations may be withdrawn and allocated to the WOAN.

In my opinion, the above two issues have had a significantly detrimental effect in terms of achieving the broadband penetration targets as set in the SA Connect policy, and it is for this reason that I do not believe we have the political will to service the population of South Africa with broadband connectivity.

However, there is hope for the future; President Ramaphosa has publicly recognised the importance of the fourth industrial revolution, including taking the initiative to appoint a Commission to investigate its adoption within South Africa.

Further, during his second State of the Nation Address (SONA) in June this year, he indicated that the new Communications Minister, Stella Ndabeni-Abrahams, will issue a policy directive by the end of July thus allowing the Regulator to commence with the process of allocating long-delayed spectrum to the mobile operators.

We hope that this deadline will be met so that the industry can move forward in terms of providing the necessary infrastructure needed to meet the targets laid down six years ago in the SA Connect policy.



*G Debbo | SAIEE President 2019*
*Pr. Eng | FSAIEE*

# The National Science and Technology Forum Awards

*From left: Mr Hoosain Karjieker, Dr Happy Marumo Sithole, Dr Philemon Mjwara*

*From left: Mr Reinhard Meyer, Dr Hlumani Ndlovu, Dr Philemon Mjwara.*

*From left: Mr Reinhard Meyer, Dr Marde Helbig, Dr Philemon Mjwara.*

The NSTF-South32 Awards were held at a prestigious Gala Dinner in Gauteng on Thursday, 27 June 2019. It is the 21st celebration of excellence through this flagship project of the National Science and Technology Forum (NSTF).

The special annual theme award was made for an outstanding contribution to *'Materials for inclusive economic development'*, in recognition of the *'International Year of the Periodic Table of Chemical Elements'* declared by the United Nations.

The NSTF is the most representative multi-stakeholder non-profit forum in South Africa promoting SET and innovation. The NSTF-South32 Awards showcase the research and development capacity of our nation. The excellent output of the winners supports South Africa's advancement, economic growth and the social upliftment of our people.

The awards were celebrated along with over 600 guests and more than 50 different organisations from the broader community. It is an honour to be nominated, an outstanding achievement to reach the finals and an exceptional milestone and celebration of excellence to win one of these awards.

The winners are:

**Lifetime Award:**
**Prof Robin Crewe**
Senior Research Fellow: Centre for the Advancement of Scholarship, University of Pretoria (UP)

**TW Kambule-NSTF Award:**
**Prof Lindiwe Innocentia Zungu**
Executive Dean: Graduate Studies, Unisa – University of South Africa

**TW Kambule-NSTF Award - Emergin Researcher:**
**Dr Mardé Helbig**
Senior lecturer: Computer Science Department (Dept), UP

**Dr Hlumani Ndlovu**
Lecturer: Division of Chemical and Systems Biology, Dept of Integrative Biomedical Sciences, University of Cape Town (UCT)

**Management Award:**
**Dr Happy Marumo Sithole**
Director: Centre for High Performance Computing (CHPC), CSIR – Council for Scientific and Industrial Research

**Engineering Research Capacity Development Award:**
**Prof Alison Lewis**
Dean: Faculty of Engineering and the Built Environment, UCT

**Prof Elvis Fosso-Kankeu**
Associate Professor: School of Chemical and Minerals Engineering, North-West University

**NSTF-Lewis Foundation Green Economy Award:**
**Ms Nicoleen Janse van Rensburg,** University of Johannesburg
Process, Energy & Environmental Technology Station (UJ-PEETS)

**NSTF-Water Research Commission (WRC) Award:**
**Prof Martine Visser**
Director: Environmental Policy Research Unit; and Professor: Economics, School of Economics; and Research Chair: African Climate Development Initiative, UCT

**Data for Research Award:**
**Prof Tandi Matsha**
Department of Science and Technology / National Research Foundation SARChI (South African Research Chair Initiative) Chair: Cardio Metabolic Health, Cape Peninsula University of Technology


*From left: Mr Simphiwe Madlanga, Prof Tandi Matsha, Dr Philemon Mjwara.*

**Innovation Award:**
**Centre for Rapid Prototyping and Manufacturing (CRPM) Unit, Central University of Technology**
Director and Team Leader:
Mr Gerrie Booysen

**Innovation Award: Small, Medium and Micro Enterprise:**
**Hydrox Holdings (Pty) Ltd Team**
Chief Executive Officer and Team Leader:
Mr Cornelis Johannes de Jager

**Communication Award:**
**Wits Communications Services**
Head: Shirona Patel, Wits

**Non-Governmental Organisation (NGO) Award:**
**Eskom Expo for Young Scientists**
Executive Director: Mr Parthy Chetty

**Special Annual Theme Award:**
**Prof Alexander Quandt**
Acting Chair: Materials for Energy Research Group; and Focus Area Co-ordinator: Centre of Excellence in Strong Materials, University of the Witwatersrand

The winners were awarded with state-of-the-art trophies, manufactured with advanced materials (titanium), a first in SA.

# E-commerce depot gets up to speed with 98 LTP-B standard inverters


*Rudie Venter*

When a major local e-commerce company had to install additional conveyor belts due to its growth, it found the perfect answer for its requirements in the MOVITRAC® LTP-B standard inverter from SEW-EURODRIVE (Pty) Ltd.

The complete automation package supplied by the drive and automation specialist included mechanical gearboxes and Variable Speed Drives (VSDs) to cope with the increased demand at its client's main depot.

SEW-EURODRIVE (Pty) Ltd Mechatronics Representative Rudie Venter reveals that 98 MOVITRAC® LTP-B inverters and accessories were supplied.

Most VSDs ship with individual PROFINET communications cards. However, in this instance, a communications gateway was supplied to which a total of eight drives can be connected at the same time, reducing installation cost dramatically. Without the gateway, the installation would have required 98 individual PROFINET cards.

The gateway communicates with a central system such as SCADA. It gives feedback on aspects such as whether the drives are running and their physical location, in addition to feedback from limit switches along the conveyor.

The standard inverters are matched to meet the requirements outside of the control cabinet. These inverters are developed for open-loop speed control of asynchronous and synchronous motors without encoder. Therefore they are ideal for conveyor applications, hoists, fans, and pumps.

MOVITRAC® LTP-B is available in six sizes, with power ratings from 0.75 kW to 160 kW. It is especially suited for use in dusty and humid environments. As an alternative, inverters for installation in a control cabinet in the power range from 0.75 kW to 15 kW are available with IP20 ingress protection.

The VSDs installed for this project, which is being commissioned at present, are for torque and speed control in a conveyor application. These drives, with their simple set-up, are DIN rail-mounted, meaning no need for drilling and screws during installation, which is quick-and-easy as a result.

A particular advantage of the MOVITRAC® LTP-B series drives is a ramp-up and ramp-down feature to extend the lifespan of the gear unit by limiting inrush currents, which can damage the motor windings. The motors used are the latest IE3 premium efficiency versions available.

# INDUSTRY AFFAIRS

## Young women engineers make a difference in their communities and in the industry

*From left: Moreblessing Chipango, Miché van Rensburg and Davina Ramadhin*

There's a new breed of engineers in South Africa: they're young, professional, generous and passionate about the world around them. Most importantly, they're women.

During youth month, Norconsult Iyanda (Pty) Ltd – a Black Women Owned Electrical Engineering company honoured three powerful young women in their company, working in a traditionally male-dominated engineering sector.

Junior engineer Moreblessing Chipango, 29, Engineer-in-training, Davina Ramadhin, 28 and Engineering draftsperson, Miché Van Rensburg 29 are creating a spark in the industry.

While they are all fully engaged with the professional field of Electrical engineering, they also all share an interest in the health of the planet and take a keen interest in Renewable Energy.

Said Thuli Njapha, Managing Director of Norconsult Iyanda: *"We're very proud to be employers of these young women who are part of the next generation of cutting-edge Engineers who will shape the future."*

Moreblessing Chipango, who grew up in a family of predominantly professionals where education was a priority, knew from an early age that she wanted to do something relevant and vital, something that would make a difference in the lives of people.

*"At Norconsult, I am doing what I love and giving back at the same time. Working on electrification programmes means that I have to investigate how people live, what their needs are. I then design electrical systems to meet their needs.*

*"These are my people I am helping; my grandmother lives in a rural area. Bringing electricity to these rural communities gives me great satisfaction. It changes people's lives."*

Engineer in training, Davina Ramadhin, joined Norconsult Iyanda when she completed a BSc in Electrical Engineering at Howard College in Kwa Zulu Natal.

She said: *"I have always liked Physics and Maths, so it was a natural progression to move into the field of engineering."*

Davina has just returned from a working trip to Brno in the Czech Republic, where she was exposed to the latest global trends in Switchgear – the equipment used to protect critical parts of substations.

She was part of a team of engineers and technicians who undertook to conduct a Factory Acceptance Test at the ABB facilities for a Project Norconsult Iyanda is currently executing.

She said: *"It was exciting for me to be exposed to a different culture and learn about new and different design possibilities. I learnt, too, that terminology varies around the world, a useful lesson for the future".*

Miché Van Rensburg, who has been with Norconsult Iyanda for eight years, is a young woman making history in her field. She is one of the very few women in South Africa responsible for interpreting engineering concepts and turning them into drawings for the designs.

*"I come in between the concept and the building or installation. One of the most important aspects of my job is working with, and understanding the needs of the Engineer whose concepts Design I have to turn into plans.*

*"I am also involved in setting up projects as well as ensuring Quality Assurance of all drawings within Norconsult Iyanda."*

All three young women ascribe their passion for being fully engaged with their jobs.

They say they want to be role models for young women making career decisions.

Davina said: *"Empowerment means being able to choose whatever it is you want. In the past, women were encouraged to choose what some may consider soft subjects – like the arts. Today, I hope that girls know they can be whatever it is they want to be."*

# BI introduces industry-first multi-mount Bauer cast iron electric motor range

*Lewis Hiepner*
*BI Bauer Electric Motors Product Manager*

In an industry first, leading supplier Bearings International (BI) is introducing a multi-mount cast iron Bauer electric motor range onto the market that can accommodate the terminal box on the top, left-hand or right-hand side. The major benefit for customers is that it reduces duplicate stockholding to accommodate different terminal box positions.

Traditionally, cast iron electric motors are available in a wide range from 0.37 kW up to 400 kW, with BI only catering for top-mounted terminal boxes. *"Some plants either have top, left-hand or right-hand terminal boxes, making it a complex and costly exercise to stock all three,"* BI Bauer Electric Motors Product Manager Lewis Hiepner explains. BI itself ordered whichever variant was required ex-factory, with a normal lead time of about 14 weeks.

This is now all set to change with the industry's first multi-mount cast iron motor. BI has contracted with a major manufacturer to produce what are termed loose feet, a bolt-on addition that transforms a normal motor into a multi-mount version that is adaptable to specific plant configurations.

The Bauer motor range from BI is also available in various energy efficiency ratings, from IE1 as standard and IE2 high efficiency, all the way through to IE3 and even IE4. *"We are standardising on IE1 motors, with the possibility of being able to offer IE2 as a standard option as well, although this is still in the pipeline,"* Hiepner reveals.

The first consignment of the loose feet has arrived in South Africa. The multi-mount motor range, being cast iron, is particularly robust, and therefore ideal for the arduous operating conditions of mining operations.

*"We have received significant interest in the new Bauer multi-mount range, combined with its energy-saving potential,"* Hiepner concludes.

# Turbine Drive Train Overhauled In Just Six Weeks

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

Working in collaboration with business unit ACTOM Turbo Machines, Marthinusen & Coutts completed the work successfully within six weeks. The electrical generation plant is at Metalloys' manganese plant in Meyerton, Gauteng.

According to Mike Chamberlain, Marthinusen & Coutts' marketing executive, this achievement showcased the capacity of the divisions to take full control of large mechanical and electrical refurbishments.

Chamberlain highlights that the customer did not want to split the responsibility for the complete generator and turbine drive train between separate contractors.

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

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

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

casing. Positive material identification tests were conducted on all the studs, nuts and shaft seals. A complete 3D scan was done of the centreline to allow reverse engineering drawings.

# Schneider Electric CSI efforts receive double awards

*From left: Professor Suné von Solms from the University of Johannesburg, who forms part the F'SASEC network; Zanélle Dalglish, Head of Sustainable Development & Academy Anglophone Africa Cluster at Schneider Electric and Carina van Zyl, Sustainable Development Specialist at Schneider Electric.*

Schneider Electric South Africa has once again gained recognition for its efforts in sustainable development, being awarded both first and second place at the annual SEIFSA (Steel and Engineering Industry Federation of South Africa) Awards for Excellence on 23 May for Best Corporate Social Investment. In addition, on the same evening, Schneider Electric South Africa won the Best Business Collaboration France-South Africa at the French South African Chamber of Commerce and Industry (FSACCI) Annual Gala Awards.

## SEIFSA BEST CORPORATE SOCIAL INVESTMENT AWARD

*"At the core of our sustainable development strategy, Schneider Electric South Africa has had an in-depth focus in providing access to energy and access to education,"* noted Zanelle Dalglish, Head of Sustainable Development and Academy for Anglophone Africa.

The Isiboniso project has addressed numerous challenges and through strategic partnerships, Schneider Electric has implemented sustainable solutions. Isiboniso Primary School, situated in the impoverished community of Orange Farm, Gauteng was first introduced to Schneider Electric by Habitat for Humanity.

At the time, there was no access to grid electricity, young learners were taught on a floor in a small, dark informal dwelling and there was inadequate supply of food resources for most learners. *"Going into this project, Schneider Electric was well aware that the success of this initiative would rest on collaboration with sustainable development partners to ensure that the school's needs are well understood and addressed in a sustainable manner,"* said Dalglish.

Thus far, Schneider Electric has provided two container classrooms for the young learners and in collaboration with UJ supplied off-grid electrification through solar solutions, to power the use of computers, printing copiers and lighting in the classrooms.

The collaboration between Schneider Electric and the University of Johannesburg PEETS has also enabled a food resilience project at the school for learners deprived of nutrition, with the view of this growing into a full feeding scheme programme for the community, as the project evolves.

In addition, safe electricity workshops were run to educate learners on the suitable and safe use of electricity, with electrical plug points installed for the first time in all the classrooms.

*"Since the start of this project, there has been a significant increase in learners from 150 at project inception to 300 learners currently, which demonstrates the sustainable impact of the project. None of this was possible without the support of our partners, who need to be publicly acknowledged again for their participation,"* continues Dalglish. "They are Schneider Electric Foundation; University of Johannesburg - Department of Process, Energy & Environment Technology Station (PEETS) and the Department of Electrical and Electronic Engineering Science; the Vaal University of Technology (VUT); Habitat for Humanity; and @6 Community Development Organisation in Orange Farm.

## SECOND SEIFSA AWARD

Its second SEIFSA Awards entry, French South African Schneider Electric Education Centre (F'SASEC), received the second placed Best Corporate Social Investment Award.

# IBC SOLAR helps universities to improve Namibia's energy supply

The system house acts as an industry partner for universities from Bavaria in a pilot project for the energy supply in Africa

IBC SOLAR, a global leader in photovoltaic (PV) systems and energy storage, is supporting Bavarian universities to create a pilot project for expanding the energy supply into rural areas of Namibia. The aim of the project "PROCEED" is to achieve a sustainable improvement in the energy supply based on renewable energy. The research will also be funded by the Federal Ministry for Education and Research (BMBF) with approximately 1.24 million Euros in the next three years.

IBC SOLAR is supporting the University of Bayreuth, the Technical University of Ingolstadt and the Neu-Ulm University of Applied Sciences as an industry partner for the project in order to secure and increase the energy supply in remote areas of Namibia. The system house will be primarily responsible for the technical appraisal and long-term monitoring of existing systems during the project. This also includes developing system improvements for storage and control systems and delivering the corresponding components.

*"Solar power is now cheaper than electricity from the grid and the PV market in Southern Africa has significant growth potential,"* explains Albert Engelbrecht, Senior Vice President Solutions International at IBC SOLAR. *"We are very pleased to be helping the universities implement this project with our expertise and products. The project contains promising solutions which can also be used to improve the energy supply in other rural areas of Africa cost-effectively and efficiently,"* says Engelbrecht.

Together with the system house, the researchers will use renewable energy and stand-alone grids referred to as *"mini grids"* to implement the project. These decentralised power grids restricted to smaller areas are operated by local providers and are not embedded into a unified nationwide integrated grid. In cooperation with Namibian partners, decentralised models for the energy infrastructure will be developed in the future, which correspond to the local electricity demand, make use of current technical possibilities and are accepted by the rural population. These island grids ought to be economically viable and easy to maintain.

More than half of Namibia's rural population has no access to electricity. Connecting households to the national power grid is neither technically nor economically practical in many parts of the country. The lack of access to electricity is one of the main drawbacks in the efforts to reduce poverty and achieve industrialisation.

# ST-TALKS - introducing a new SAIEE Member benefit

A continuing question that the SAIEE Head Office and Council members keep asking is, "How can we increase the value of the SAIEE Membership to existing and future members?" Recent efforts have centred around increasing the number of SAIEE Centres, restructuring the head office to serve the members better, building up the SAIEE Training Academy and others.

**BY** | VIV CRONE
PR ENG | FSAIEE | FSAAE

All of the above add significant value, but a follow-on question has been, *"What do our Members need most in the current economic climate?"*

For a possible answer, maybe one can refer back to the founding history of the SAIEE.

The SAIEE was established 110 years ago when Johannesburg industry and especially the mining industry was burgeoning. Engineering skills were in short supply, and the mines were having to innovate to ensure that the gold was brought out of the ground at competitive rates.

What was needed was a forum for Engineers to get together (the modern term is 'network'!) and discuss their current problems, seek advice from colleagues, get mentored, identify promising upcoming Engineers looking for a change of employment and benefit from the local expert knowledge in the various Engineering areas.

The SAIEE served the above purpose, and the primary activity of the Institute was the monthly meeting, where Electrical Engineers got together to update their knowledge, network with colleagues and socialise.

Over the years, this formal monthly meeting has been lost.

Individual Centres do hold their regular meetings but do not replace the original monthly get-together of the Institute in early years.

Engineers today face similar issues to those in the early days. There is a shortage of experienced Engineers in the country, and the younger Engineers often are placed in situations that are beyond their knowledge and experience. Without easy reference to mentors or knowledgeable colleagues, they do their best but sometimes fail, with significant consequences that can extend to loss of life in the worst case but also economic losses.

So, if we can agree that Engineers today need a forum similar to the past SAIEE monthly meetings, then we propose to re-establish these regular get-togethers and expand them country-wide with the help of enabling technology.

Led by the SAIEE Publications Committee, a country-wide monthly meeting, that has the presentation parts streamed simultaneously to all SAIEE Centres is proposed. These will be linked into the **watt**now feature articles and advertising.

The goal of these meetings would be to replicate and re-introduce an opportunity for our Members to benefit from regular meeting and interacting with their Engineering colleagues. In essence, to get together to network and *"discuss their current problems, seek advice from colleagues, mentorship, identify promising upcoming Engineers looking for a change of employment and benefit from the local expert knowledge in the various Engineering areas."*

SAIEE House in Johannesburg will host the first of these new-style monthly meetings, which will focus on Lightning - as that is the theme for the August issue of **watt**now.

We are planning that the SAIEE Technical Talks or "ST-Talks" take place every third Thursday of each month, so watch for the event announcement. Other Centres will host future events, depending on the **watt**now article content to be featured.

Industry sponsorship packages are available, which will give sponsors specified benefits, including a short sales presentation opportunity of no more than 10 minutes. (Please contact Minx for more information on these).

A technical presentation will follow the short sales presentation by one (or more) of the authors of the upcoming **watt**now magazine feature technical articles - indicated by the button on the top left corner of the page.

These presentations will be similar in format to the very popular TED Talks that most of us are familiar with. These ST-Talks will be streamed in real-time, to all SAIEE Centres, where similar monthly meetings are simultaneously taking place, and pod-casts will be loaded onto the SAIEE website.

No doubt, there will be some teething problems that will have to be sorted out. No doubt the proposed format may be changed as we learn more and listen to your feedback.

However, we will continue to improve on these new-style monthly meetings, so that Members have a regular, professional 'home' to meet and network with their Engineering colleagues. We aim to offer these technical presentations and networking opportunities as a tangible benefit exclusively to SAIEE Members.

'See' you on August 22nd, 2019, for the first of these exciting monthly meetings. wn

# Changing lives in our communities

An entire community in Mpumalanga has access to proper clinic services with clean running water and a secure environment thanks to funding from KSB Pumps and Valves.

As part of the pump manufacturer's corporate social investment (CSI) its management decided to get behind the Nthoroane Clinic and assist with the upgrade of its facilities.


The facilities upgrades included the connection of its main water tank, the construction of a new main entrance with boom gates, carports for 10 vehicles, handrails for the entrance and disabled toilets, as well as paving and painting of facilities and the erection of a new guardhouse.

According to Gerald Surjoobhalee, KSB Pumps and Valves commercial manager for its service department, and one of the drivers of the project, the company provided both funding and project management for the project. This ensured direct involvement throughout and provided a window into the many milestones along the way. Equally rewarding was the development of local suppliers, contractors and labour who received appropriate training and gained valuable experience through direct exposure to the fundamentals of project management.

## PERFECT CHOICE

*"The project was undertaken after KSB Germany directly supplied four new HDC 6/ 8N pumps, and a further nine REL oil pumps to Eskom. Since KSB was the sole OEM for these products, we were obliged to give something back to the local communities through our CSI efforts. This led to a decision to reinvest a percentage of the order value back into the Grootvlei community. Nthoroane clinic was the perfect choice as access to quality health service is essential for every community, and in this region, the clinic was in desperate need of some TLC. Once the decision was made, we sprang into action and started work in October last year. By May this year, all work had been wrapped up, and the community is already enjoying the benefits of their labour,"* says Gerald.

Gerald says the company is proud of the achievement as it has brought much-needed relief for the community and the smiles and happiness of the community made the whole project worthwhile.

## WORKING TOGETHER

*"The security guards now have proper shelter when they control vehicles and the disabled patients now can use adequate safe toilet facilities within the clinic. The dedicated staff now also have safe and secure parking. Inside the clinic, patients now have proper taps with clean water, and a backup generator ensures the lights stay on even if the power goes out. Best of all, the controlled access boom gate provides staff and patients are safe and secure.*

*"Having undertaken the project alongside Eskom, we have learned that big businesses, like ours, can do a lot to help communities in need. Team efforts such as this one between state-owned enterprises and suppliers can help build a better business relationship and contribute towards healthy and happier communities in future. I believe this is the right thing to do,"* says Gerald. wn


*At the reopening of the Nthoroane Clinic were KSB Pumps and Valves' Grant Glennistor, Gerald Surjoobhalee and Patience Kotyi (far right), with Sister Thangithi Mazibuko, who is in charge of six clinics in the district.*


*Nthoroane Clinic was upgraded in a joint effort between Eskom and KSB Pumps and Valves recently.*

# The Gwakwani Project

The Gwakwani Project (in Limpopo) is an initiative that is headed by Research Connect, from the School of Electrical and Electronic Engineering at the University of Johannesburg (UJ). The project aims to provide the rural village of Gwakwani with off-grid solutions where facilities that would else be inaccessible.

**BY I** BRANDON ORMOND

The Gwakwani Project has been in operation since 2014 with the most recent visit during the first week of June 2019. The mission of UJ Research Connect is to enable the students to be a part of the broader community by participating in real-life engineering projects. This year some members of the University of Johannesburg's South African Institute of Electrical Engineers Student Chapter (UJ SAIEE SC) were allowed to visit the Gwakwani Project.

## BACKGROUND

In 2013, the School of Electrical and Electronic Engineering identified a rural village that would significantly benefit from electrification, even on a small scale. Gwakwani is home to just under 100 people and situated 670 km from Johannesburg of which the last 70km is a gravel road. Its remote location made it infeasible to provide electrical services from the national grid, and the water supply for the village was via a diesel-powered pump.

In March 2014, a team from the UJ School of Electrical and Electronic Engineering (consisting of seven employees, four fourth-year students) and an international journalist, partnered with Grundfos, Vision Automation and Clever Devices and Designs. With the backing of the village leaders and local counsellors, they installed a solar-powered pump system and two extra solar panels that are used to supply the village with four essential outside flood lights, one inside pump house light and one power outlet to be used for charging of cell phones and battery powered lanterns. These have made a tremendous positive difference.

In 2015 solar lights were installed in every household to enable children to do their homework and just making life a bit lighter. These children leave home at 4 am to start the long and tedious walk to school to only arrive back home at 7 pm, after dark, making homework a challenge. The engineering students took this task upon themselves to designed and implemented a mini solar grid. By installing streetlamps has allowed for better interaction in the evenings with the villagers feeling more secure.

In 2016, with the assistance of the industry partners, a solarise powered crèche and bakery were built in the community. The establishment of the crèche meant the pre-school children no longer have to walk 6km to the nearest centre of learning. The crèche, with a television and DSTV, has had a significant impact on the young children and exposes them to the rest of the world outside. The solar bakery has stimulated the economy in this rural area by providing full-time employment to eight people from the village. The bakery produces between 120 and 160 loaves of fresh bread every day. There is now a constant supply of fresh bread and confectionaries every day, which was also a considerable challenge.

During the June 2019 trip, a Sigfox station was built and commissioned, as well as a cold storage facility. IDC sponsored the cold storage unit. The most recent trip focused on these as well as maintenance of all previously installed facilities.


*From left: Christopher, Ross Beukes, Dr Deon Sabatta, Brandon Ormond, Tshepo Mawer, Nicolas Hattingh, Prof Johan Meyer, Ashwin Van Der Merwe, Tinashe Makamure, Phillip Ndlovu, Prof Sune von Solms and behind the camera Cornay Keefer.*

*Working on the Sigfox radio station.*


*Sigfox Radio Station*

*Running maintenance on the batteries for the bakery.*

*Working on the electrical system for the cold storage.*

## THE TRIP

Five members of the UJ SAIEE SC (Ashwin Van Der Merwe (Member), Brandon Ormond (Chairman), Phillip Ndlovu (Member), Tinashe Makamure (Member) and Tshepo Mawer (Social Media Manager)), as well as two other UJ students (Nicolas Hattingh and Ross Beukes), accompanied members of UJ Research Connect (Cornay Keefer (Project Manager), Dr Deon Sabatta (Senior Lecturer), Prof Johan Meyer (Head of School: Electrical Engineering) and Prof Sune von Solms (Associate Professor)) to Gwakwani. As previously mentioned, the purpose of this trip was to carry out maintenance on the facilities (such as painting structures and geysers, testing batteries), and to install solar streetlamps and fit extra insulation for the cold storage.

The installed equipment can be monitored via the Sigfox radio system which is sponsored by Sqwidnet. The students are actively involved in these activities.

Additional partners involved in this project are the Industrial Development Corporation (IDC) (who provided financial support for this trip), Schneider Electric (supplied vital components such as the solar street lamps and so much more) and Sqwidnet, who provided the communication modules that were installed as well as technical support.

## THE EXPERIENCE

The experience of going on this trip is unsurpassed with the learning from the implementation of theory, that is taught and learnt in lectures, to be able to give back to the people of the village, to have had the opportunity of working from the brilliant minds and experiencing the mentorship of the UJ Research Connect team.

The students in the UJ SAIEE SC would like to thank all those that were involved in this unforgettable experience. As the Chairman of the UJ SAIEE SC, I would like to extend a special thank you to Prof Sune von Solms for introducing us to the project and being the catalyst that started this adventure. To Dr Lesedi Masisi for being the Student Chapters Supervisor as well as organising the banners.

A huge thank you to Tshipise Forever Resort for their excellent accommodation and to the Fortress of Refuge Foundation (FRF) who donated treats for the children of the village. wn

# PROTECTING WIND POWER ONE TURBINE AT A TIME: the need for proper earthing and lightning protection

Florian Vögerl, Head of Sales and Operations at DEHN Africa, says, *"in 2016, a study by the Council for Scientific and Industrial Research (CSIR) noted that the capacity to produce electricity from wind turbines in South Africa was more widely spread than initially thought, and was in fact on par with solar energy."*

*"Since then, wind energy is becoming an increasingly important part of this renewable landscape. Here at DEHN Africa, we play a critical role in protecting wind turbines that are used in renewable energy production from the destructive effects of lightning and power surges."*

## RENEWABLE ENERGY IN SOUTH AFRICA

Locally, the energy landscape is in a certain state of upheaval, best summed up around the ongoing uncertainties and delays related to the Department of Energy's latest draft Integrated Resource Plan for electricity (Draft IRP 2018). The draft IRP walks a delicate tightrope among a number of different stakeholders, including the government, labour, business and communities, and issues at stake include (but are not limited to) those who want to continue for as long as possible with coal-fired energy production, largely because of job continuity; a small number voting for nuclear; and an ever-growing voice clamouring for the final green light for renewable energy sources.

Vögerl comments, *"when you think that, as per the CSIR, the cost of new wind generation is 40 percent cheaper than that of coal, it does make enormous sense to explore wind energy as a renewable energy option in South Africa. This is especially true as we have vast areas of the country that are very windy, such as the Eastern and Western Cape provinces, and parts of the interior. Additionally, the average time for construction to completion of renewable energy projects is only 1.9 years, which obviously allows a new source of energy to be connected to the grid very quickly."*

*"At DEHN Africa, we are obviously aware that legislative issues still need to be enacted around the implementation of different energy sources in the grid overall. But I think it remains a certainty, amidst all the noise, that more wind turbines will be required in South Africa, and they need to be protected against lightning strikes and electricity power surges – quite literally, one turbine at a time."*

## PROTECTING RENEWABLE ENERGY EQUIPMENT FROM LIGHTNING STRIKES

Lightning strikes to renewable energy equipment, such as that used on wind or solar farms, or rooftop solar panels, will cause damage at the strike point, as well as surge damage to any equipment that is connected downstream. While external lightning protection helps avoid damage at the strike point itself, surge protection devices help prevent downstream damage because of conducted and induced surges from the strike, while further allowing the renewable energy system to stay online.

In addition to the damage that an individual lightning strike can do, it must also be considered that South Africa is a country where many areas have a very high lightning ground flash density (a measurement of the number of lightning strikes to the ground over a period of one year). There are, in fact, areas where the country's ground flash density is comparable to, or higher than, the lightning hot spots of north and south America, Asia and northern Australia.

*"South Africa's lightning conditions,"* says Vögerl, *"are in general more frequent than those found in many parts of Europe, where much of the world's renewable energy sources and technology are developed and implemented. We therefore have even more reason, arguably, to look after our renewable energy equipment than our colleagues in Europe do. Therefore, it is critically important to protect our renewable equipment in South Africa from lightning strikes. The results of a lightning strike to an unprotected renewable energy source will include physical repairs or replacement – not to mention potential reputational damage."*

He clarifies that, in some cases, wind turbines are imported into South Africa with the lightning protection equipment already pre-assembled, and that DEHN Africa's work requests are mostly around the earthing of the turbines.

## APPROPRIATE EARTHING FOR WIND TURBINES

In this vein, says Vögerl, the earth termination system for onshore wind turbines has the following tasks:

- Protective earthing, which safely connects electrical equipment to the ground and protects people and property in the event of an electric fault;
- Functional earthing, which needs to ensure safe and efficient operation of the electrical and electronic equipment;
- Lightning protection earthing, which must safely conduct the lightning current from the down conductors to the ground.

DEHN advises in a white paper on the earth termination of on-shore wind turbines that, as regards lightning protection earthing, it is advantageous to have a single, common earth-termination system for all purposes (medium-voltage system, low-voltage supply, lightning protection, electromagnetic compatibility, telecommunication and control systems).

The white paper notes further that the reinforced concrete foundations of wind turbines should primarily be as a foundation earth electrode, as these provide a low earth resistance and represent an excellent basis for equipotential bonding. As a medium-voltage transformer is also installed in the wind turbine, the earth-termination system must be designed according to international standard IEC 61936-1, which describes all types of earth electrodes. Foundation earth electrodes are defined as the most effective earth electrodes.

When working out the dimensions of the earth termination system, it is important to factor in the composition of the surrounding ground, and the type of neutral point treatment and the resulting short circuit currents in case of a fault.

## MOVING FORWARD

*"We believe that South Africa is on the verge of seeing a tremendous increase in the use of renewable wind energy production. When the green light is given for even more investment in the renewables space and the finalisation of the draft Integrated Resource Plan for electricity, companies will want to move quickly with their wind energy production plans. With this in mind, the time for planning is now, and it should be remembered that each wind turbine needs to be earthed properly and individually,"* concludes Vögerl.

During National Water Week in March 2019, Dr Kevin Winter of the University of Cape Town's (UCT) Future Water Institute, said that it is an apposite moment to explore the state of South Africa's water resources. And the outlook is not good, he cautioned, adding that unless there is significant action by 2030, there will be a projected 17% shortage in water supply.

**BY: KEVIN WINTER**

The deficit, as stated by the Department of Water and Sanitation's (DWS) Master Plan, may even be under-reported, Winter added.

*"The plan acknowledges the current state of water resources. The crisis is real. Greta Thunberg, the 16-year-old environmental activist who spoke at Davos about climate change, put it bluntly,* 'I want you to panic ... our house is on fire'.

*"The Master Plan is a 'call to action', and rightly so. The report begins with a frank admission that the house is in serious trouble and it is going to take a Herculean effort to deal with multiple fires."*

## EXTENT OF THE CRISIS

The *"call to action"* outlines the usual themes that explain the causes of the crisis, he continued.

*"But this time it offers a level of detail that is uncharacteristic of the DWS and breaks rank with the tradition of the former National Water Resources Strategy report (NWRS2) (2013) which was descriptive, fluffy, and has contributed little to progress in water management. NWRS is another lost report.*

*"If 'water is life' then the current water crisis should never have been allowed to happen. The reality, as reported by the Master Plan, is caused by a lack of investment in water infrastructure and maintenance, resulting in an alarming 56% of all wastewater treatment works and 44% of water treatment works being categorised as in a poor or critical condition, while 11% are described as dysfunctional."*

The lack of investment is partly explained by the fact that 41% of municipal water does not generate any revenue, while a further 35% is lost through leakage. DWS estimates that it will take R33 billion each year for the next 10 years to achieve water security, and avoid a 17% deficit.

The current budget for DWS is R15.5 billion and the National Treasury has no plans to increase this amount over and above inflation for the foreseeable future. There is a significant financial shortfall. The gap in access to water and sanitation is also unacceptable, said Winter.

Over 3 million people cannot access a clean water supply and 14.1 million do not have safe sanitation. Only 64% of South African households have access to a reliable water supply service. The link between access to

safe, clean water and sanitation and the cost of medical services to support people who live in unhealthy conditions is unknown.

## COUNTING THE COSTS

*"The logic is if you fix the water services then it will reduce the medical burden and costs to the country."* Similarly, the overall cost of deteriorating water quality and resultant loss of environmental and ecological resources is unknown.

The DWS Master Plan reports that between 1999 and 2011 there was a 500% increase in the deterioration of the ecological condition in South Africa's main rivers, pushing them beyond the point of recovery.

*"The call to action is loud and clear. The house is on fire and is putting human and ecological health at huge risk."*

# South Africa's water: new 'call to action'

The Master Plan and schedule for actionable items is detailed. It includes deliverables, priorities and costs, but also a litany of claims as to why certain actions have not been achieved to date. These include a lack of commitment, poor leadership, lack of responsibility and insufficient revenue, said Winter.

*"The Master Plan has only just begun, but the final column on achievements to date doesn't make for good reading. The call to action is faltering."*

## WHAT NEXT?

No one who is actively engaged in the water sector doubts the enormity and complexity of water resource management. Bold action plans are required to prioritise and guide actions, but success will be hard to achieve – for four major reasons:

DWS and stakeholders in the water sector cannot achieve the plan alone or by trying to manage the proposed actions in the traditional top-down approach. The challenge is too big. Deliverables outlined in the plan are too broad and are missing clearly defined benchmarks and metrics from elsewhere in the world.

DWS's current budget is far too small. It will need to double its budget each year for the next 10 years to avoid a 17% shortfall in water supply alone by 2030. Without an independent water regulator, the accountability is limited. Independent regulators don't necessarily work, but there is an argument for a smart, businesslike approach that is capable of building investor confidence and public trust. At the same time the regulator will have to be both a referee and a player, providing accountability and visionary leadership. That seldom works, but independent regulator structures and roles will need to be different to what we currently know.

*"There is no doubt that the Master Plan is a well thought-through and comprehensive document. It exudes fighting talk. However, what is at stake is the capacity to implement these plans such that they will enable South Africa to adapt much faster to multiple drivers of change, and not only climate change and population development,"* said Winter.

*"Above all, this Master Plan can't afford to fail. It's time to panic and not wait for 2030."*

Read the Draft Master Plan here.

*© Courtesy of University of Cape Town*

# What Cape Town's drought can teach other cities about climate adaptation

Extreme weather events, such as Cyclone Idai that has recently devastated Beira, Mozambique, and Hurricane Harvey that hit Houston, USA, in 2017, are the types of climate extremes that cities increasingly have to prepare for.

**BY** | PROF GINA ZIERVOGEL

Cities, particularly those with extensive informal settlements in the developing world, are being hit hard by these new climatic realities. Although rapid onset disasters often have devastating effects, slow onset climate events, such as drought, can also be detrimental.

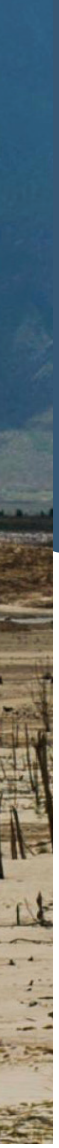
Cities need to build their capacity to adapt to this range of impacts. One of the best ways to do this is to learn from other cities' experiences. Drawing lessons from other places that have gone through climate crises is a good way to guard against future shocks and stresses.

One very recent case that cities around the world are watching is Cape Town's severe drought and the threat of "Day Zero" – when the city's taps were due to run dry. Although the city came close to having to turn off the taps, they managed to avoid it. After better rains in 2018 and significant reduction in water use across the city, the dams are now reassuringly fuller than they were in 2017 and 2018, although caution is still needed ahead of the winter rains.

A lot has changed and it's important to reflect on and share.

I conducted research to establish some key lessons to be drawn from the Cape Town drought. I found that local governments must focus on several important areas if they're to strengthen urban water resilience and adapt better to climate risk.

These include improving data collection and communication, engaging with experts and enabling flexible adaptive decision-making.



# When the well is dry, we learn the worth of water.
## - Benjamin Franklin

And, crucially, I found that governance must be strengthened. Although three years of low rainfall led to very low dam levels, there were breakdowns in the interaction between national, provincial and municipal governments that exacerbated the problem.

### THE FINDINGS

The research suggests that effective water management requires systems of mutual accountability between spheres of municipal, provincial and national government.

In South Africa, the national Department of Water and Sanitation is responsible for ensuring that sufficient bulk water is available, often in dams, that can be transferred to municipalities. The municipalities are then mandated to provide clean drinking water. This means that intergovernmental coordination across the spheres of government is vital.

As it stands, different spheres' mandates overlap. This creates confusion and means the buck is often passed: one sphere of government will insist a particular competency isn't its job, and hand the work on to another sphere.

For this to be resolved there has to be clarity on shared responsibilities and roles, as well as the development of mutual accountability. To achieve this, technical skills, personal and institutional relations need to be strengthened. This requires strong leadership.

Collaboration within municipal departments also needs to improve. The Cape Town drought highlighted the importance of this. Before 2017, there was limited collaboration between city departments on water issues. During the drought, however, collaboration between certain departments increased considerably as the complexity of the crisis became clear.

Not only is collaboration within government important, it needs to extend beyond government. During a crisis, all of society needs to be engaged, including citizens and the business sector. Technical expertise need to be balanced with opportunities for a broader group to share its perspectives and concerns. Partnerships can help gather the range of perspectives and support needed to respond to complex problems.

Municipalities that, during the course of their normal business activities, have developed strong relationships with their stakeholders will be better placed to respond effectively to a crisis. That's because they will be able to harness stakeholders' collective knowledge and contributions more easily.

In Nelson Mandela Bay, the Business Chamber has done this by strengthening relations with the municipality to help to facilitate the ease of doing business in the city. They recognise that all businesses require electricity, water, transport and logistics, for example, and so focus on improving these areas. The municipality developed task teams made up of volunteers from their member companies who have skills set in those areas.

Importantly, there is an agreement that the Metro places high-level executives to sit in the task team meetings to ensure plans are put into practice. These types of relationships can be invaluable during a crisis.

### MOVING FORWARD

While my study focused on Cape Town, its findings can be applied to other cities that want to strengthen their ability to adapt to climate change. Yes, cities need to pay more attention to how climate variability impacts on their resources, particularly water. But just as important is strengthening the governance of the water system.

A well-adapted city is one that understands who is responsible for what and has strong trust and partnerships between and within government.

In order to build capacity to adapt, new types of skills are needed. Local government needs to pay more attention to how to build partnerships, enable flexibility and support learning.

These are the types of skills needed for a well-adapted city, but still often lacking in local governments. wn

Earn CPD Credits

Whether upgrading existing water infrastructure or building new assets, there is an increasing role for smart technologies and data to be used in order to maximise the reliability, affordability, and flexibility of the network. "Smart" sensors with embedded microprocessors and wireless communication links have the potential to fundamentally change the way water utility civil infrastructure systems are monitored, controlled, and maintained.

**BY |** PASCAL MOTSOASELE
SMSAIEE

South Africa's biggest bulk water utility, Rand Water, has over ZAR6.5-billion worth of investment in reservoirs. Due to the cost, magnitude and strategic importance of these reservoirs, it is imperative for the water utility to invest in asset health monitoring systems, particularly structural health monitoring systems.

This article explores a wireless smart sensor structural health monitoring solution for reservoirs at the water utility, taking into consideration the life cycle management of the civil structures.

## INTRODUCTION

Rand Water has in excess of 60 strategic reservoirs that supply and serve the clients a nominal 4350 mega litres per day (MLD) of potable water. The reservoirs range in storage capacity from 4 mega litres to 650 mega litres. The design life of our reservoirs is a minimum of 50 years, but with a proper condition-based maintenance regime in place (i.e. an overhaul every 25 years), this is extended to 80-100 years. Figure 1 gives the life cycle of our reservoir assets.

As part of the maintenance regime, we note that some components of the structure (e.g. jointing materials and steelwork) have shorter lifespans than the structural concrete. Over the lifespan of the overall asset, maintenance emphasis is placed on such components since they require periodic renewal during the life of the reservoir – Rand Water employs visual inspections to determine and assess the condition of the assets. The aim with the periodic inspection and appraisal is to identify at an early stage, symptoms and signs of deterioration and structural distress (cyclic fatigue cracking) to timely

rectify by remedial measures, repair or refurbishment. Condition triggers for refurbishment include repairs to joints, and (re-)placement of bandages. Over and above the condition-based renewal triggers, the utility has also undertaken to spend 5% of the replacement value every 25 years on scheduled refurbishments (i.e. 0.2% per year of replacement cost).

# Improving reservoir structural health monitoring

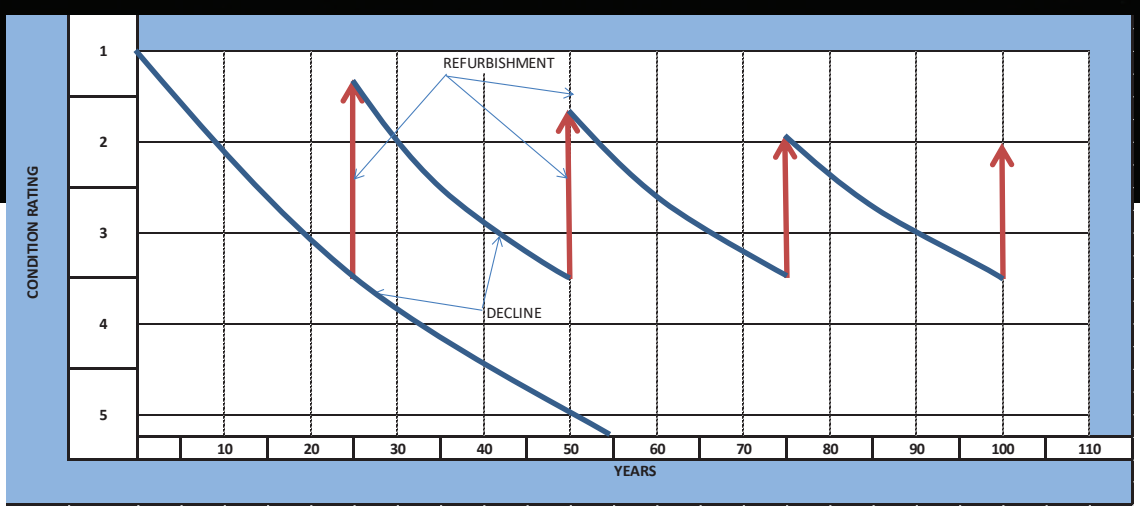



*Figure 1: Life cycle of Rand Water reservoirs.*

# Reservoir Structural Health

continues from page 27

Rand Water's reservoirs are well maintained and are currently appraised at condition rating 2 on Figure 1, which means that they are in a good physical state despite some having been put into operation in 1935.

The problem with the current method of appraising the condition of these assets through visual inspection and time-based maintenance is that it is guesswork. Structural failure can occur despite these interventions.

This article surmises that it is therefore possible to employ modern technology to effect more accurate and real time physical appraisal of the reservoirs whilst also unlocking cost and labour efficiencies.

## SMART SENSOR TECHNOLOGY SOLUTION

The Fourth Industrial Revolution is upon us, and with it comes the ability to deploy low power wireless smart sensor technology that provides an advanced and comprehensive visualisation of reservoirs' structural health in situ.

The ability to periodically and automatically inspect, monitor and report on the condition of the reservoirs is not only crucial for the safety and reliability of operation of these reservoirs, but it is crucial also for the safety and protection of maintenance personnel, the environment and our customers and surrounding communities.

A smart sensor technology solution for reservoir health monitoring will help Rand Water to reduce the costs of inspection and schedule-based maintenance, while also improve structural reliability through accurate and timeous condition reporting.

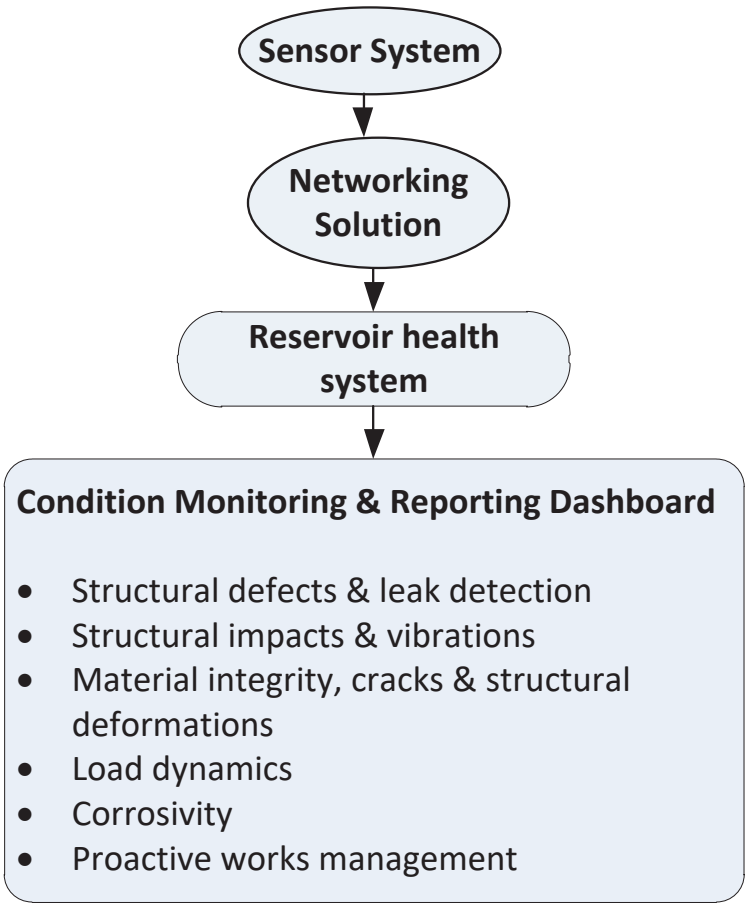



*Figure 2: High-level architecture of the reservoir health monitoring solution.*

### 2.1 SOLUTION ARCHITECTURE

The three components of the solution architecture are the sensor system, a networking solution and an asset health platform. The sensor system is coupled with ancillaries such as power provisioning and connectivity electronics.

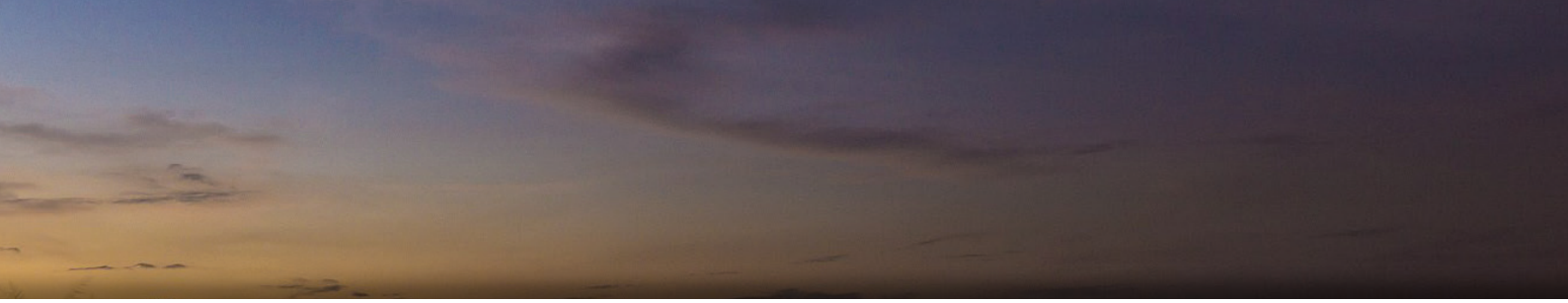
The networking solution is made up of a wireless communication module for transmission of data from the sensor to the back-end systems. And the reservoir health platform performs the necessary analytics for asset condition reporting and to produce actionable intelligence that activates maintenance interventions. Figure 2 depicts this architecture.

### 2.2 PARAMETERS TO BE MONITORED BY THE SMART SENSORS

With the use of this technology, the structure will now have self-sensing and self-diagnostic abilities. The on-structure parameters to be measured by the sensors are:

- Material integrity
- Structural impacts and vibrations
- Cracks and structural deformations
- Structural temperature gradient
- Load dynamics (water levels, flows and pressures) including load distribution
- Environmental corrosivity

These parameters are monitored so as to meet the requirements of safety, durability,



serviceability and sustainability during a reservoir's relatively long lifespan. When any of the set parameters are triggered, the system will inform the back office by logging and raising a warning alarm. This then eliminates the need to schedule costly routine inspections (costly in terms of human labour and outage of the reservoir to conduct inspections), which improves operational efficiency, improves maintenance and the asset health monitoring regime, and reduces financial wastage.

**2.3 TYPE OF SENSORS AND RELATED SENSING TECHNOLOGY**

Low power wireless sensor networks are currently commercially available, and are made up of light-weight electronic devices with a small form factor, that are capable of functioning off of harvested energy sources (e.g. solar, vibration, thermal), can measure both environmental (e.g. temperature gradient, corrosivity), and mechanical (e.g. stress, load distribution, material integrity) parameters, and can support advanced diagnostics and analytics for predicting structural health and remaining useful life.

Literature is available on research undertaken to develop the various passive and active sensing technologies and devices. Hui and Jinping (2011) delve into the technical details of fibre optic stress wave sensors, PZT sensors, cement-based strain gauges, temperature sensors, corrosion sensors, nanomaterial-based acoustic and vibration sensors, and other wireless sensors that are commercially available. The water utility simply needs to identify the parameters they wish to monitor and feed into the health monitoring platform at the back office, for analysis and to activate maintenance efforts.

2.3.1 SENSORS FOR ENVIRONMENTAL CONCERNS

Environmental factors including gradient temperature, humidity, rain (rain fall, raindrop and so on), chloride, salty, acid, alkali, etc., impact the long term performance of a reservoir's structure. Based on the monitoring data, a zone map of environmental actions similar to the zone map of earthquake ground motion parameters can be developed, which will provide criteria to evaluate the life-cycle performance of the reservoir (Hui and Jinping, 2011).

2.3.2 SENSORS FOR SAFETY EVALUATION AND RELIABILITY PREDICTION

Available literature points to the fact that safety evaluation of a whole structure is difficult to determine because the real failure modes cannot be quantified. The smart sensor health monitoring technology may provide a potential solution. In general, performance deterioration of materials reduces the bearing capacity of a structure. The bearing capacity of a reservoir can thus be determined from the variation of the structural performance evaluated by using the monitored data, or from durability analysis that can be factored into the analytics algorithms. In fact, available literature (Liu, Li & Ding 2006; Ding, Li & Liu, 2008; Li, Bao & Ou, 2008) is still inconclusive in deriving an accurate deterioration evolution of a structure using existing approaches.

However, from a structural integrity point of view, the vibration sensor empowers us to collect real-time data of normal vibration under operating conditions, which can then be used in pattern recognition techniques to determine any anomalous vibration on the reservoir structure over time. We note that databases exist that allow one to identify specific types of damage from particular features of the vibration signature (Farrar & Worden, 2007). This information can then be fed into the asset health platform for further processing.

Additionally, regular scanning using 3D-laser techniques based on scattered electron microscopy (SEM) may be used to detect small cracks on the concrete layer.

For the reservoir floor structure, 3D-radar and infrared imaging techniques may be used to determine the bearing capacity of the slabs and the load transfer between them, and the bearing of the soil support, sub-base or foundation platform (Domínguez, García & Goñi, 2015). This data can then also form part of the inputs to the asset health platform.

**2.4 NETWORKING DEPLOYMENT CONFIGURATION OPTIONS**

Over and above the choice of powering the devices (e.g. small battery and/or harvested energy sources), current wireless designs show an affinity towards open standards and interoperability, allowing the deployment to be configured as per client requirements around the choice of communication technology (e.g. Zigbee, Wi-Fi, Cellular, satellite).

Moreover, the compact small factor, together with the use of galvanised steel enclosures, allows for easier vandal-proof designs and corrosion mitigation through cathodic protection. Figure 3 shows the logical design of the smart wireless sensor network.

# Reservoir Structural Health

continues from page 29

Multiple wireless transducers are mounted on the reservoir structures and exposed to the elements and in some instances harsher environmental conditions. The set of sensors will use ultra-low power electronics and efficient power management techniques to allow for extended battery operations and/or energy harvesting. Wireless communications between nodes will allow for data consolidation and evaluation on-structure, and with remote data access being provided via a backhaul network such as cellular, fibre, microwave radio or satellite uplink.

The back office will then collect the data at a predetermined frequency, and analytics algorithms will be activated to produce actionable asset health intelligence and decision support.

**2.5 ASSET HEALTH PLATFORM**

The backend system collects the data from various smart sensors and deposits it into a centralised data repository. The system performs analytics to determine the near-real-time condition of the reservoirs against a set of pre-configured parameters. This is then logged and displayed real time on the built-in visualisation node, with trending over time also incorporated into

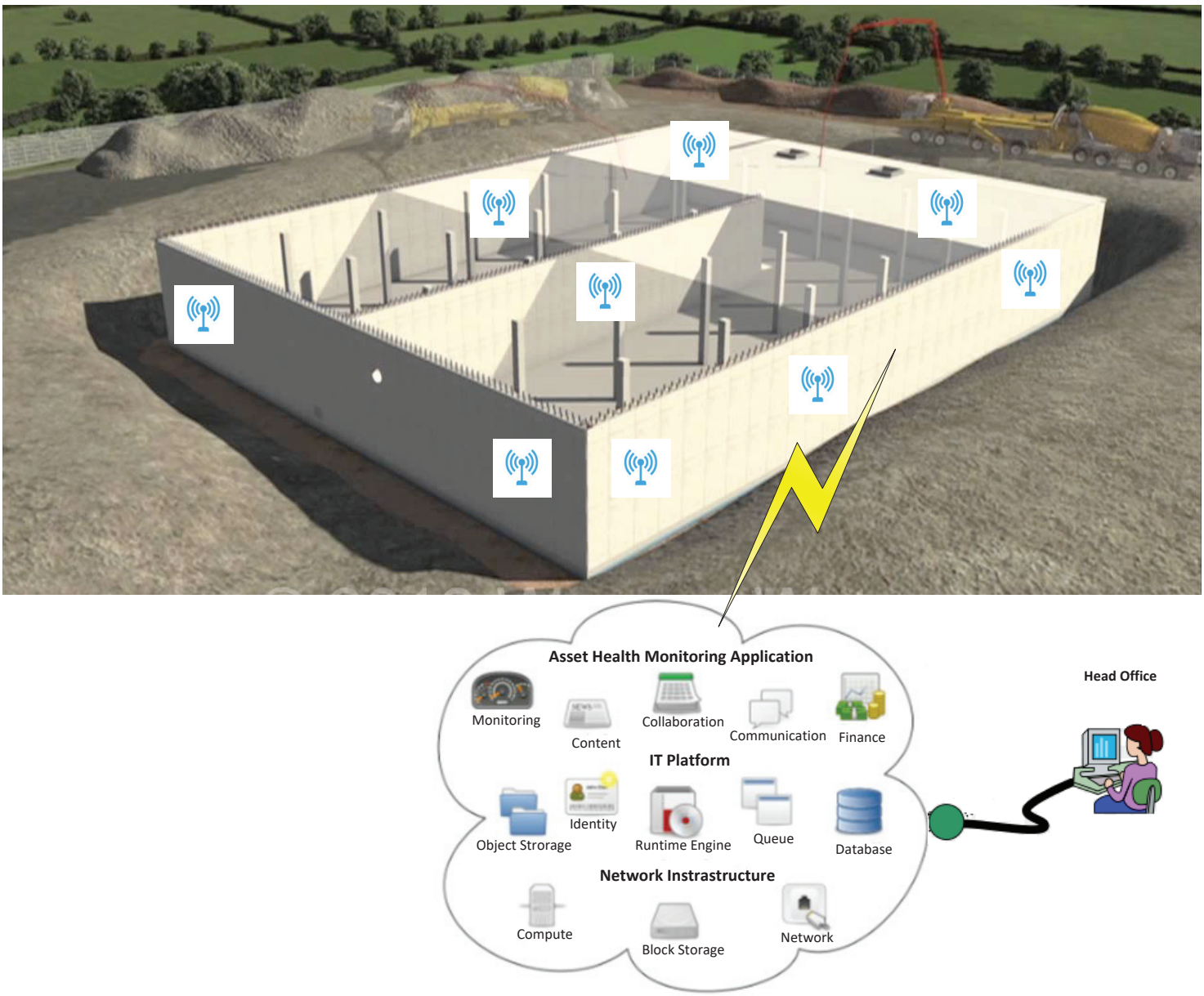



*Figure 3: Deployment of a wireless smart sensor network for reservoir health monitoring.*

the dashboard. Figure 4 is an example of visual reports that may be produced by the platform. In this case, the graph relates to the condition of the reservoir as regards to corrosion.

## CONCLUSION

Smart sensor technology solutions offers Rand Water the opportunity to transmit asset condition data from the reservoir structures to servers in real time, throughout the life cycle of the structure, for structural heath maintenance and continued monitoring. The solution will assist in accurate and timely reporting of the asset's condition, and in effecting cost and labour efficiencies by avoiding unnecessary time-based visual inspections. wn

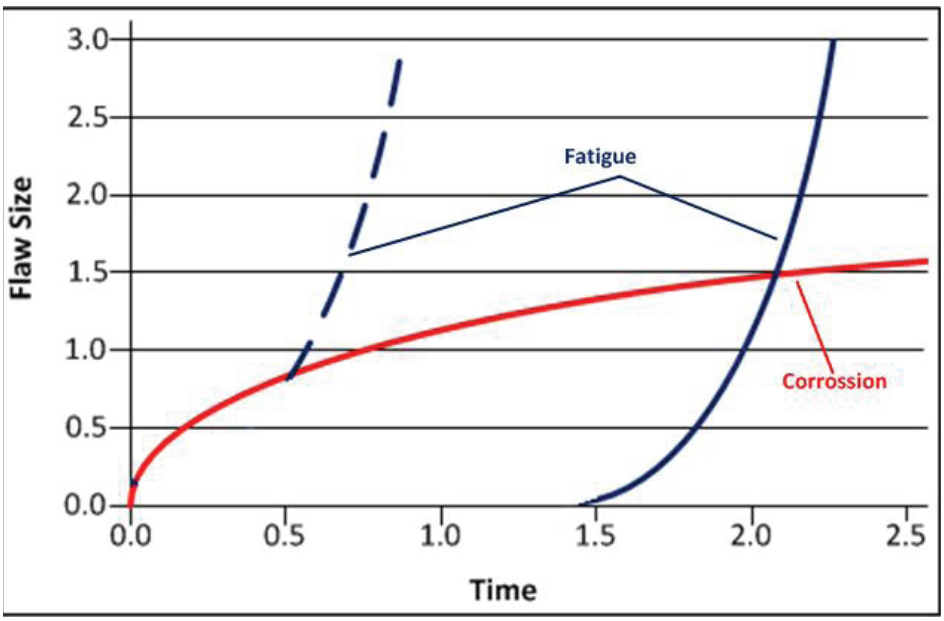



*Figure 4: Example of a possible built-in model showing how corrosion strongly influences damage due to mechanical effects in structures. [source: Lunar Inc.]*

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# A DELICATE BALANCE - water scarcity in South Africa

South Africa is currently overexploiting its renewable water resources. Moreover, withdrawals are forecast to increase in all three sectors (agricultural, industrial and municipal). Meanwhile, much of the country's water infrastructure is in disrepair and dam levels are dangerously low. This report presents a national-level forecast of water supply and withdrawals until 2035, before exploring alternative scenarios. It is possible to restore stability to South Africa's water system, but it will take significant financial investment and political will.

**BY** | ZACHARY DONNENFELD | COURTNEY CROOKES | STEVE HEDDEN

Although the 2014–2016 drought has catalysed a national conversation and, to some extent, brought water security into the policy debate in South Africa, the drought did not cause water scarcity. What the drought did was highlight existing vulnerabilities in South Africa's water system, and properly frame the magnitude of the challenge of ensuring water security for the country.

South Africa is a water-scarce country. There are existing, affordable technologies that government, business and private individuals could employ to help realign supply and demand while ensuring water security for future generations.

South Africa's water picture has not appreciably stabilised since the African Futures Project (AFP) – a collaboration between the Institute for Security Studies (ISS) and the Frederick S Pardee Center (Pardee Center) for International Futures – published the first national-level supply and demand forecast for water in the country in 2014.[1]

At the same time, the International Futures (IFs) model – developed and housed at the Pardee Center at the Josef Korbel School for International Studies at the University of Denver – forecasts that demand will increase in all three sectors out to 2035 (agricultural, industrial and municipal). This increase in water demand is being driven by a combination of population growth, urbanisation, rising incomes, irrigation expansion, non-renewable electricity generation and a growing manufacturing sector.

Moreover, the Intergovernmental Panel on Climate Change anticipates a decline in average precipitation levels in the western part of the country, and that the entire south-western region of South Africa will be at increased risk of severe drought throughout this century.[2] While the January and February rains of 2017 have offered a brief reprieve from the 2014–2016 drought, the fact is that South Africa is still overexploiting its renewable water resources and, without additional interventions, will continue to do so for the foreseeable future.

The 403 mm that the country received in 2015 was the lowest annual total on record since the South African Weather Service began collecting rainfall data in 1904. Moreover, the 2015 drought came on the back of three consecutive years of below-average rainfall, making it the most severe and prolonged drought since the 1940s.[3] This caused South Africa's average dam levels to plummet from around 93% in March 2014 to a low of 48% in November 2016.[4] At the national level, dam levels recovered in early 2017, but have declined and are now considered 'moderately low' (they stood at about 59% in February 2018). However, dam levels are only part of the story.

According to the Department of Water and Sanitation's (DWS) National Integrated Water Information System (NIWIS), 146 of South Africa's 565 rivers are categorised as having 'very low' flows, while a further 105 are 'low' and another 88 'moderately low', as shown in Figure 1.

Put another way, more than 60% of South Africa's rivers are currently being overexploited. According to the Organisation for Economic Co-operation and Development, only one-third of the

# A Delicate Balance

continues from page 33

country's main rivers are in good condition, and one-quarter of its river ecosystems are critically endangered.[5]

The consequences of overexploitation may not be evident overnight but, 'the ultimate losers are the exploited aquatic ecosystems and the organisms (including humans) dependent on them for survival and well-being'.[6] Moreover, a national-level picture necessarily obscures essential regional differences, and some areas of South Africa remain in a critical state.

The Western Cape is the most severely affected area. Average dam levels in the Breede-Gouritz catchment were at 20% in February 2018 (considered 'low' for the January/February season), while the Berg-Olifants catchment was at 35% (considered 'very low'). More than 80% of rivers are being overexploited in those two catchments.

The problem is not limited to the Western Cape, though. Dam levels have been plummeting in the Eastern Cape as well, which is experimenting with the same level of voluntary water restrictions as having been imposed in Cape Town.[7] KwaZulu-Natal is also overexploiting about 50% of the rivers in its primary catchment (Pongola-Mtamvuna), where dam levels are at about 52% (or 'moderately low' for this time of year).

## SCOPE

This report builds on previous work from the AFP on the future of water availability in South Africa. The most recent publication in this series – "Parched prospects II: A revised long-term water supply and demand forecast for South Africa (hereafter 'Parched prospects 2')" – was released in March 2016.[8] This body of work has explored the future of South Africa's water sector using IFs.

In the IFs model, total water demand (withdrawals) is disaggregated by sector and includes municipal, industrial and agricultural withdrawals. Total water supply is broken down by surface water, groundwater, direct use of treated municipal wastewater, desalinisation and fossil water.

To enhance the precision of previous forecasts, the AFP has endeavoured to improve the water model of IFs. With funding from the Water Research Commission (WRC), the AFP has enhanced each aspect of water withdrawals (agricultural, industrial and municipal) in the model. Related variables in the model now drive each of these demand sectors. Moreover, the model now also uses a price mechanism to equilibrate supply and demand to create a more dynamic representation of the way water systems evolve.[9] Table 1 gives a brief overview of the

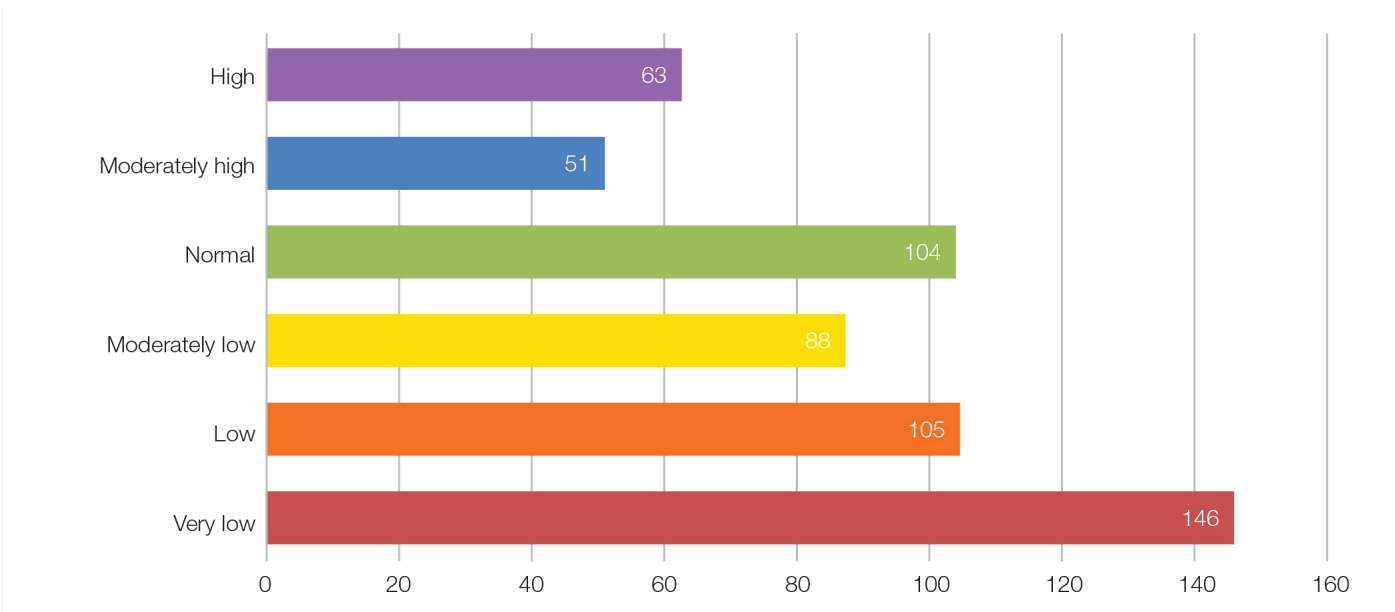
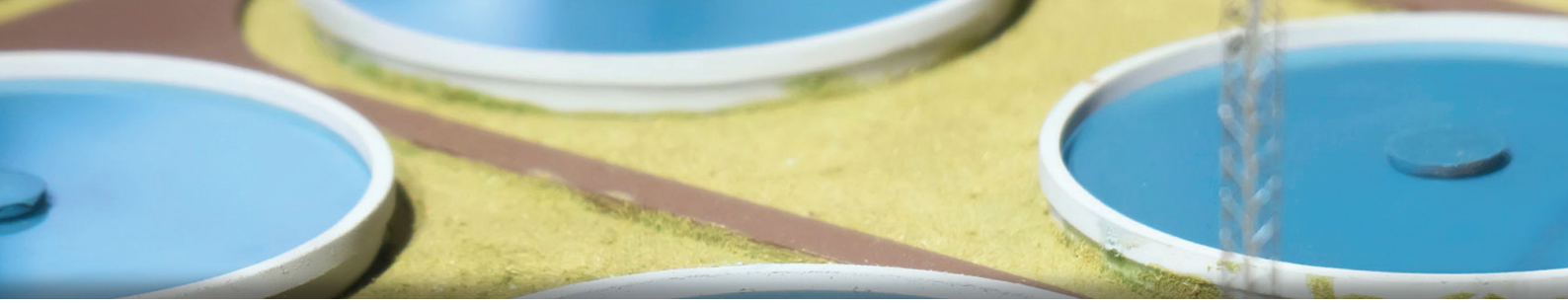



*Figure 1: Rivers in South Africa categorised by average flows.*



| WATER SECTOR | CORE DRIVERS |
|---|---|
| Agricultural | Area of irrigated land (+), |
| Industrial | Size of manufacturing (+), amount of generation capacity from non- renewable sources (+) |
| Municipal[10] | GDP per capita (PPP) (+), number of piped water connections (+), urban population size (+), a portion of the population living in urban areas (-) |

*Table 1*

main drivers of water demand by sector as represented in the IFs model.

In other words, IFs now has a water model that interacts with the other models in the IFs system – including the models for demographics, economics, agriculture, energy and the environment.[11] This will allow users to interrogate the implications of various development strategies and how policy goals compete with or complement each other concerning water scarcity.

## IMPLICATIONS OF MODEL DEVELOPMENT

Because water supply and demand now dynamically interact in the model over time, water demand can be either constrained or enabled by available supply. Likewise, supply will be affected by changes in demand. In other words, the model has built-in 'rebound effects'. In a water-scarce system where constraints are imposed, these rebound effects can manifest as efficiency measures, but others will come at the cost of reduced agricultural yields.

The two demand scenarios shown in Figure 2 represent two potential futures for South Africa. The first scenario (from Parched prospects 2) is a future where South Africa continually overexploits its water resources with truly unknowable consequences for people, wildlife and the general ecological sustainability of the country's major surface water systems – the 'Unconstrained Scenario'.

The second scenario, from the revised water model with equilibrating dynamics, is a future where economic and human development is constrained by water scarcity – the 'Constrained Scenario'. This second scenario represents a more plausible future, but also a much more challenging one.

While it may appear to be 'good news' that South Africa's overexploitation seems less severe in this revised demand forecast, that improved water balance will have to be achieved through incredibly aggressive efficiency measures. This more balanced forecast will also come at the cost of decreased agricultural production, which could make the country more vulnerable to international commodity shocks and threaten food security over the long run.
IFs now assumes that a country will recognise that it is overexploiting its renewable water resources and will implement measures to reduce demand and force convergence with the exploitable limit over time.[12] This new forecast assumes that South Africa will be able to reduce demand by about 1.2 $km^3$ in 2035 (relative to the previous forecast). This amount is equivalent to nearly three-quarters of the total withdrawals of the industrial sector in 2016. A decrease of this magnitude would not be without historical precedent, but would the exception, rather than the rule, for upper-middle-income countries.[13]

In the Constrained Scenario, municipal water demand per capita is reduced by 7.5% by 2035, compared to 2015 values. These efficiency measures are imposed despite over 16 million additional people moving to urban areas, about 4.5 million other people gaining access to piped water connections, and average incomes rising by 33% by 2035. Achieving this will take a combination of water-saving technologies and behaviours, as well as a reduction in non-revenue water.[14]

Likewise, in the Constrained Scenario, the agricultural sector will need to become more efficient. In the Constrained Scenario the model assumes a reduction in the amount of water per hectare of irrigated land of 2% by 2035, compared to 2015 values (i.e. water use in agriculture becomes 2% more efficient in this scenario). This could be driven by more advanced irrigation technologies, as well as a shift away from water-intensive crops.

The Constrained Scenario is a future where South Africa responds to increased water scarcity primarily through better water conservation and demand management policies. Irrigation expands by about 180 000 hectares by 2035, leading to an increase in agricultural water demand, although water per irrigated hectare decreases. Also, all of the supply interventions in Figure 2 are implemented on time and to specification. If the supply does not increase based on those plans, then the demand forecast will be lower,

# A Delicate Balance

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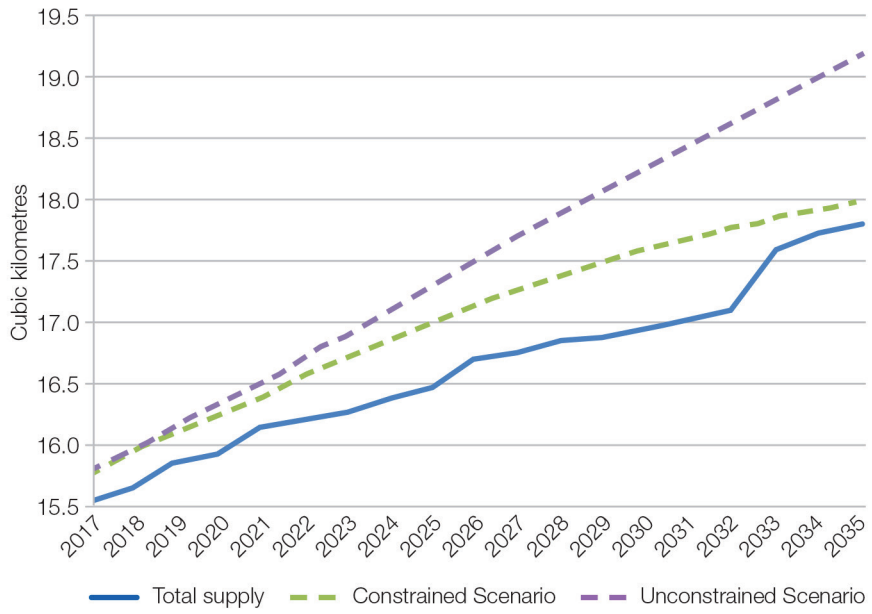



*Figure 2: Change in demand forecast after model revisions.*

and the efficiency measures and effects on irrigation will be more severe.

Alternatively, the government could choose to pursue an expansion of irrigation, but that would require either further supply increases or more efficiency increases. That scenario (Agricultural Trade-offs) is explored in detail in the sections below.

So, even with a dynamic model where withdrawals are constrained based on available supply, South Africa is forecast to continue to overexploit its water resources throughout the forecast. This can have devastating effects on water ecosystems and could ultimately impact the quality of water throughout the country.[15]

## CONSEQUENCES OF OVEREXPLOITATION

When water is extracted from river systems at unsustainable levels, it reduces the overall amount of water flowing downstream, which affects the ability of the river ecosystem to properly absorb the by-products associated with human life (e.g. industrial discharge or fertiliser run-off). When effluent discharges occur downstream from where water is extracted for human consumption, and there is an insufficient volume of water in the river to dilute the chemicals and microbials present in the (raw and treated) effluent discharge, the ecosystem can begin to deteriorate.[16]

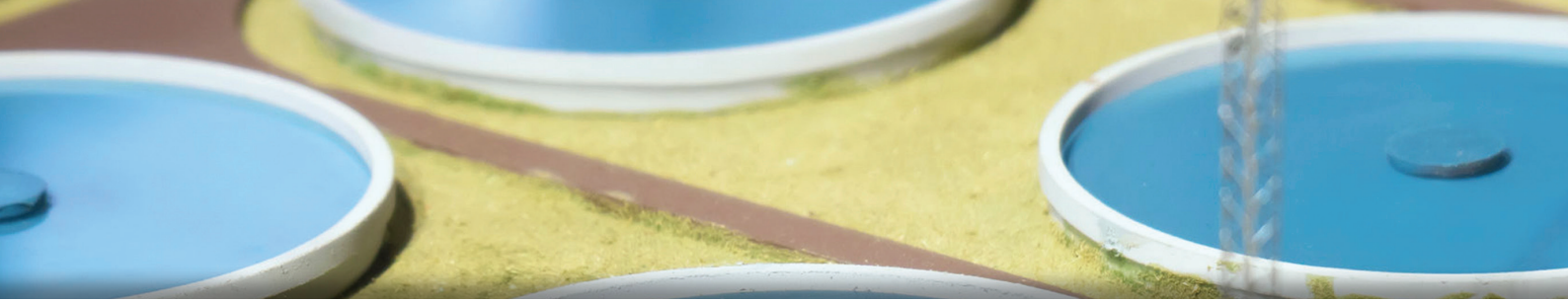
This imbalance between effluent discharge and river flows can manifest as water temperature increases, higher concentrations of chemicals and microbials, or changes in dissolved oxygen and pH levels.[17]

When water resources are overexploited for a prolonged time, this interaction between human activity and deteriorating water quality is amplified. Other things being equal, adding more people to a community that is overexploiting its renewable resources will not only exacerbate the impact on water levels, but those additional people will also engage in other activities that add more affluent to the hydrological system.[18] In other words, more pollutants are being added to less water, making it increasingly difficult for the water system to dilute those particulates and regenerate itself efficiently. When the ability of a river to effectively absorb potentially harmful particulates is diminished, there are substantial consequences for human development including an increased risk of contracting a waterborne disease.[19]

Contaminated water is a significant driver of diarrheal disease, which alone is responsible for roughly 1 600 dead children per day, according to UNICEF.[20]

Even when children survive a bout of diarrheal illness, they may suffer from undernutrition or stunting. Stunting has negative consequences for both physical and cognitive development and can hinder people's ability to progress through school and inhibit the productivity of the workforce over the long term.[21] Poor water quality may also result in an increase in vector-borne diseases from mosquitoes, tsetse flies and ticks, mainly when the water is so polluted that it is not disturbed by humans and where the eggs of insects can survive for extended periods in a dormant state.[22]

Also crucial to the South African context, is that overexploitation in one area can have negative impacts on downstream communities that are not overexploiting their local resources.



As shown earlier, certain areas of the country are suffering from far more severe water stress than others, and if any province or municipality were to run out of water entirely, it would quickly become a national emergency. Many parts of the country remain drought disaster zones, with the hardest-hit areas being the Karoo and the western coast.[23] In the past year, the City of Cape Town in the Western Cape province has twice had to invent new levels of water restrictions. These now stand at level 6b, and residents are limited to 50 litres of water per day.

Moreover, there has been a fairly consistent decline in dam levels around the Cape Town metro area. The province is gravely concerned about the loss of its water supply, with a near panic erupting around a possible 'Day 0' when the region could potentially run out of water entirely.[24]

This would indeed be a crisis, but even tightly constrained water supplies could result in unmet basic needs, the continued deterioration of water quality and negative environmental consequences.[25]

Besides, if some residents from Cape Town were to leave, that would place enormous stress on already overexploited water systems in other parts of the country.

Finally, water systems that are overexploited for a substantial period become more vulnerable to the impact of external shocks such as droughts, floods and other extreme weather events. Although droughts in South Africa are inevitable – and likely to become more prominent and severe in the south-west of the country in the future – the gravity of their impact can be mitigated by efficient management of the water system.[26]

## CURRENT WITHDRAWALS AND SUPPLY

To forecast water withdrawals, IFs relies on data from the United Nations Food and Agriculture Organization's (FAO) Aquastat database, which has data for South Africa from 2013 on withdrawals in all three sectors. IFs uses Aquastat data to ensure that data are standardised across

# A Delicate Balance

continues from page 37

countries, and also because Aquastat withdrawal categories are mutually exclusive, so withdrawals are neither double-counted nor underrepresented. Agricultural withdrawals are defined by the FAO as including 'self-supplied water for irrigation, livestock and aquaculture purposes', while municipal withdrawals consist of the total water withdrawn from the public distribution network.[27] Industrial withdrawals are defined as self-supplied consumers that are not connected to the public distribution network.[28]

In line with global trends, the agricultural sector is the largest consumer of water in South Africa, using approximately 9.7 km$^3$ (about 63% of total withdrawals) in 2015. The FAO estimates that, globally, about 70% of total available freshwater is used by the agricultural sector, although that figure varies fairly dramatically by region.[29]

The next most significant user of water in South Africa is the municipal sector, which used about 4.2 km$^3$ (about 27% of total withdrawals) in 2015. Finally, the industrial sector accounted for about 1.6 km$^3$ (about 10% of total withdrawals) of consumption in 2015. Figure 3 shows total withdrawals by industry in South Africa, against the global average.

A 2012 WRC study found that, at about 235 litres per capita per day (l/c/d), per capita, water consumption in South Africa is above the global average of approximately 175 l/c/d.[30] One driver of high use is the high level of non-revenue water in South Africa.

Non-revenue water refers to the 'difference between the amount of water put into the distribution system and the amount of water billed to consumers' .[31] Non-revenue water can generally be categorised as falling into one of three categories: real or physical losses that occur because of leakage owing to poor operation and maintenance; commercial losses caused by meter manipulation or other forms of water theft; and unbilled authorised consumption, which includes water used by the utility for emergency purposes such as firefighting.

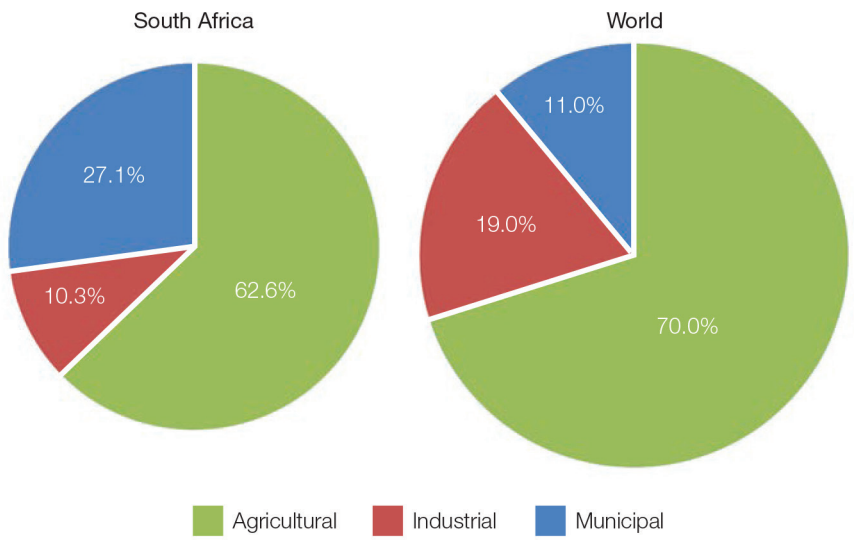


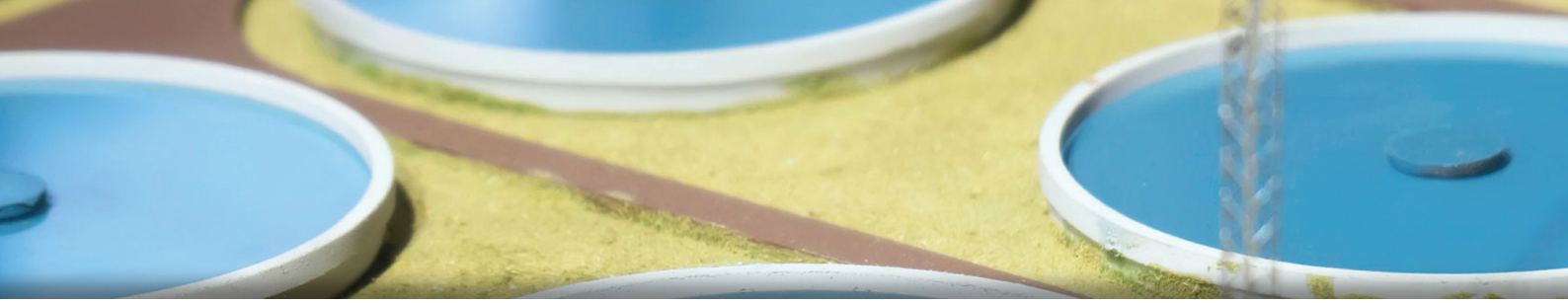

*Figure 3: Total withdrawals in South Africa and the world by sector.*

According to the latest (2012) DWS data, approximately 36% (or nearly 1.5 km$^3$) of municipal water consumption in South Africa was non-revenue.[32] Of that 1.5 km$^3$, about 70% was from real or physical losses and another 17% from commercial losses.

Although the level of non-revenue water in South Africa is on par with the global average, it is significantly higher than in other water-stressed countries. For example, Australia has limited its non-revenue water to roughly 10%.[33] If South Africa were to accomplish a similar feat, it could reduce total withdrawals in the country by 1.1 km$^3$ – or approximately 75% of total estimated industrial withdrawals in 2017.

## FORECAST OF WITHDRAWALS AND SUPPLY

While agriculture is forecast to remain the sector responsible for most of South Africa's total water withdrawals, the most significant increase is expected in the municipal area. By 2035 the municipal sector will account for roughly 32% of total withdrawals, against 28% in 2017, whereas the agricultural and industrial sectors will account for about 58% and 10% respectively. The increase in municipal consumption is driven by South Africa's growing and rapidly urbanising population, rising incomes in the country and an increase in the percentage of the people with access to piped water. Figure 4 shows a snapshot of the evolution of water withdrawals by sector in 2017 and 2035, respectively. Although the municipal sector is expected to account for the majority of additional



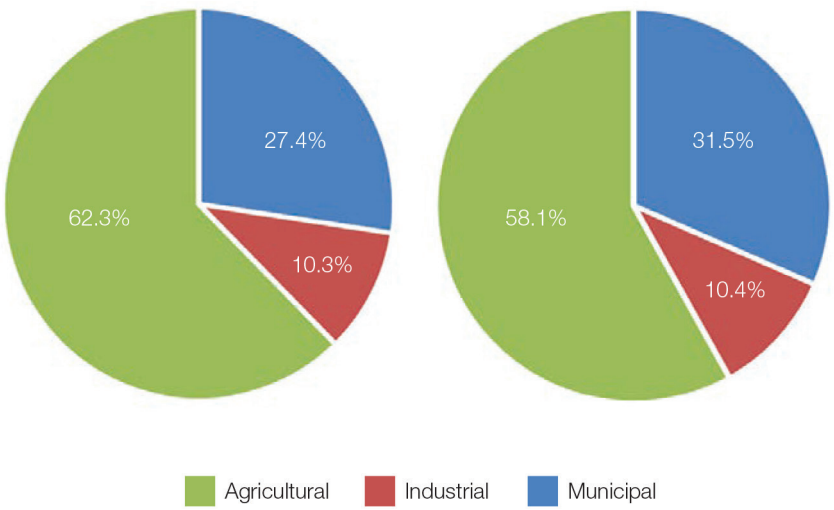



*Figure 4: Water withdrawals by sector in South Africa in 2017 (left) and 2035 (right).*

withdrawals, water demand is forecast to increase in all three divisions. In absolute terms, municipal water demand is forecast to increase by 1.3 km$^3$, industrial demand by 0.2 km$^3$, and agricultural demand by about 0.5 km$^3$ from 2017 levels by 2035 in the Current Path forecast.

One potential reason for the failure to sufficiently plan for increased water demand is that there are some reasonably significant discrepancies between the assumptions behind the forecast in IFs and those of South Africa's National Development Plan (NDP). The first distinction to highlight is that the IFs population forecast is quite a bit higher than that of the NDP. The NDP outlines five potential demographic futures, with a mean population size of about 59.3 million people in 2030. In contrast, the IFs Current Path population forecast for South Africa is approximately 62.6 million people by 2030.[34] Not only will these 3.3 million additional people require water for personal use, but the enhanced demand for food and electricity caused by this larger population will also place further stress on the food, water, energy nexus.

Part of the reason for this difference is that IFs initialises its population forecast from a higher total fertility rate (TFR) than envisaged in the NDP. While IFs assumes that the average woman in South Africa had roughly 2.5 children in 2011, the NDP assumes that the TFR was 2.3 births per woman in 2011. That may seem like a trivial distinction, but a 0.2 difference in TFR in a country the size of South Africa would result in about 2.7 million fewer (or additional) children being born.

There are also other discrepancies between the IFs forecast and the NDP. For example, IFs forecasts that roughly 80% of South Africa's citizens will live in urban spaces by 2035, while the NDP expects that figure to be more like 70%.[35] A difference of 10 percentage points would be about 6 million additional people living in cities – based on the IFs population forecast. IFs also forecasts that South Africa will add another 4.5 million new piped water connections between 2017 and 2035.

Finally, the Current Path forecast assumes that South Africa will remain heavily dependent on coal. Thermoelectric power generation is a significant driver of industrial water demand (mostly for cooling), and the Current Path forecast is that coal will remain the dominant fuel source for South Africa until 2035. IFs forecasts that thermoelectric power generation will become more water-efficient, however, owing to the implementation of dry-cooling technologies by 2035.

A separate issue with coal in South Africa is that many power stations are situated in catchment areas that are under stress.[36] This makes them vulnerable to overexploitation, as well as highly sensitive to any potential contamination resulting from industrial activity.[37] A recent report found that the Mokolo Dam Crocodile River Water Augmentation Project – which is intended to supply water to the Medupi power station – will divert more than 80% of its water for power generation and mining and could 'pose significant risks to the population's right to food, water and health'.[38] Moving the country away from a coal-based energy profile and increasing the share of renewables will reduce industrial water demand and free up water for use in other sectors.

Parched prospects 2 included a water supply forecast that was constructed by combing through the National Water Resource Strategy 2 (NWRS2), along with every large-scale reconciliation strategy published by the DWS. This forecast includes all publically available information at the time of writing about any additional

# A Delicate Balance

continues from page 39

plans, delays or cancellations of previous projects, in a slightly revised supply forecast shown in Figure 5.

Those strategies do not cover the whole of South Africa, but they do address all the major urban centres and sources of supply (i.e. the country's major rivers). The vast majority of these plans are large-scale infrastructure projects aimed at increasing the amount of surface water in the country.

The outcome of all these interventions is that the total water system is forecast to yield approximately 17.8 km$^3$ in 2035, against a revised withdrawal forecast of ± 17.9 km$^3$. It is important to emphasise though, that this supply forecast depends on the ability of South Africa to implement – on time and to specification – every planned reconciliation strategy identified above.

The result of the modelling improvements and adjusted supply forecast is that – despite a demand reduction of about 1.2 km$^3$ from the Unconstrained Scenario – South Africa continues to see a period of prolonged overexploitation before supply and demand begin to reconcile.

## POTENTIAL SOLUTIONS TO SOUTH AFRICA'S WATER CHALLENGES

Although South Africa's water challenges seem daunting, there are available, affordable solutions to some of the most pressing problems posed by water scarcity in the country today. So far, the overwhelming majority of proposed solutions in South Africa have focused on increasing the overall level of surface water, mainly through massive infrastructure projects such as the construction of new dams.

However, as previous research from the AFP has indicated, even those strategies, if implemented on time and to scale, are insufficient to meet South Africa's growing water needs in the absence of demand constraints.

In other words, without a combination of existing plans, additional strategies to access previously underused sources of water and some measure of demand management, the water sector will begin to constrain the country's ability to meet other development objectives.

## WASTEWATER TREATMENT

According to the latest Aquastat data (from 2009), South Africa only treats about 54% of its municipal wastewater.[40] Furthermore, its existing wastewater treatment infrastructure requires substantial

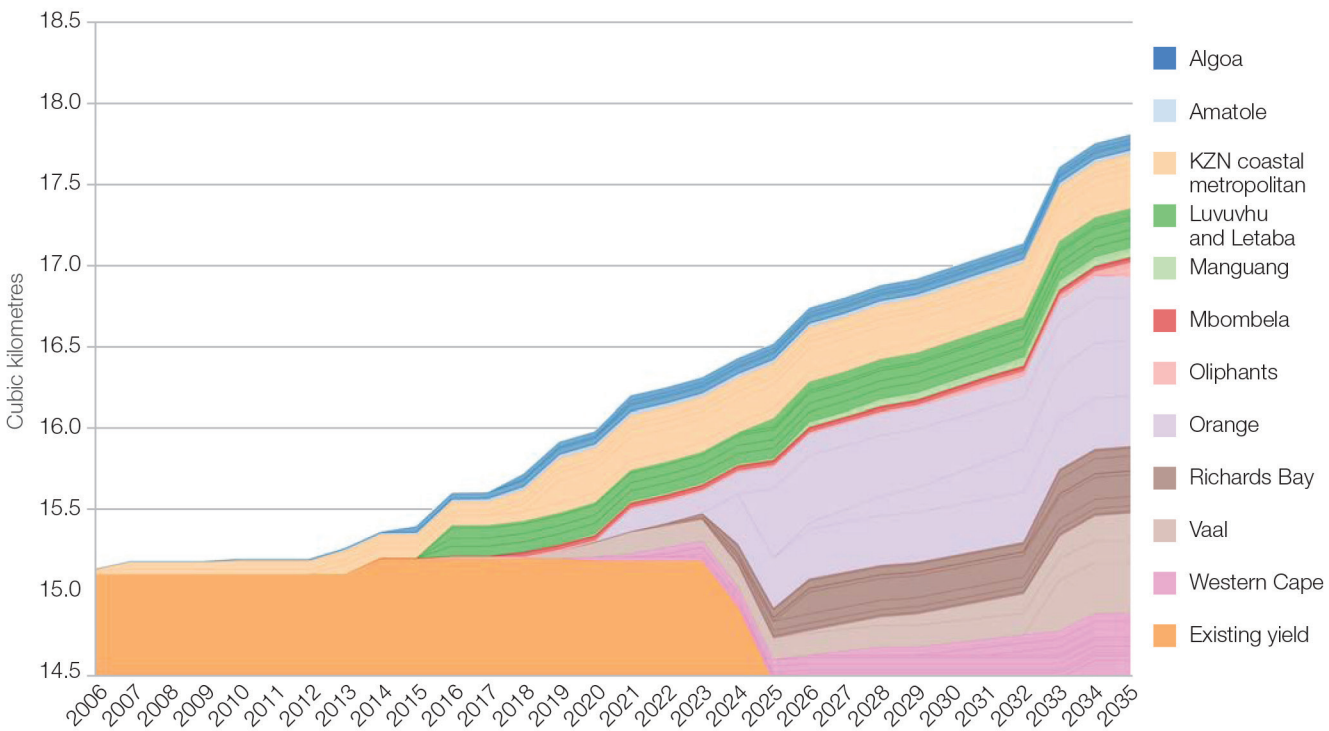
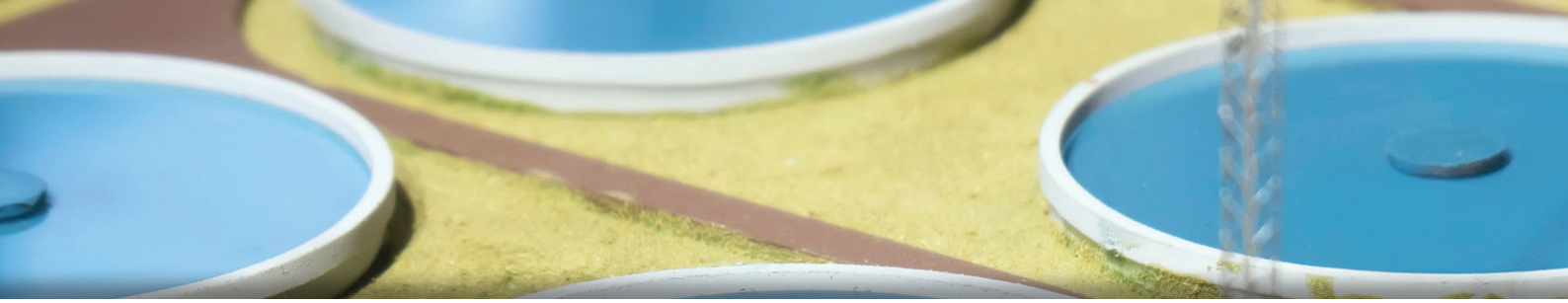



*Figure 5: Planned increases in yield extracted from all published large-scale reconsiliation strategies.*



investment. The 2014 Green Drop Report concluded that nearly a quarter of South Africa's wastewater treatment facilities are in a 'critical state', defined as needing urgent intervention, while roughly another quarter is defined as 'high risk'.[41]

Although seven of the ten reconciliation strategies analysed for this report set targets for increasing the use of treated wastewater, those interventions amount to roughly 0.22 km$^3$ or less than one-quarter of the projected gap between supply and demand in the Unconstrained Scenario in 2035. While the proposed interventions are a step in the right direction, there is undoubtedly a more significant role for treated wastewater in South Africa than currently envisioned in the major reconciliation strategies.

Between May and June 2017, the non-governmental organisation AfriForum tested the water sewage systems in 88 towns and found that two-thirds (59) did not meet national quality standards.[46]

This is an increase of more than 100% relative to 2016 (when 26 plants did not meet minimum standards) and, according to AfriForum, could 'pose a threat to human health, food security and the environment'.[47]

This increase in the number of insufficiently operated or maintained water sewage treatment plants points to some available strategies for municipal water authorities to improve water quality and potentially increase supply. Moreover, the poor quality of water treatment plants is just one indication of the country's deteriorating water infrastructure, in addition to the issue of non- revenue water discussed earlier.

## NON-REVENUE WATER

While the amount of non-revenue water is roughly on par with the global average, South Africa is considered a 'high' water-stress country by the World Resources Institute, and cannot afford to let its water infrastructure fall into further disrepair.[48]

The South African government has committed to a 'War on Leaks' campaign that aims to reduce the level of non-revenue water in South Africa by employing 15 000 South Africans as plumbers and artisans by the end of 2018. Although the campaign is being implemented unevenly throughout the country, most of the focus seems to be on KwaZulu-Natal and the Eastern Cape.[49]

## GROUNDWATER

Parched prospects 2 pointed out that groundwater was likely an underutilised resource in South Africa. Since then, the DWS has published estimates of how much groundwater could potentially be available in the country and suggests that utilising groundwater more intensively, particularly in the agricultural sector, could be a fruitful source of additional water.[50] The DWS estimates that close to 85% of the country's groundwater aquifers are under-allocated and that there could be as much as 4.8 km$^3$ worth of exploitable groundwater in South Africa.[51]

Nobody can say with any certainty if that groundwater estimate is accurate or not because the kind of in-depth, scientific study necessary to establish a reliable figure has yet to be completed. Further, groundwater is a delicate resource and needs to be managed cautiously. Nonetheless, the DWS estimate does suggest that a modest increase in groundwater use, provided that it was done sustainably, could act as one prong of a strategy to improve water security in South Africa.

## WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WCWDM)

South Africa must price water more deliberately. WCWDM strategies may be an essential element of its effort to ensure stability in its water sector. However, the legacy of apartheid and the extreme levels of structural inequality require a delicate and nuanced approach to water pricing.

Tiered water pricing is a well-established system of water conservation that has proven its effectiveness in other parts of the globe. Tiered pricing works by charging customers based on how much water they use. Customers who use more than the level deemed necessary for human consumption pay a higher rate for that additional water.

Nelson Mandela Bay has already begun to implement tiered pricing. In that municipality, customers pay R14.57 for the first 1 000 litres per day, R29.46 (per 1 000 litres) for the next 3 000 litres and R58.92 (per 1 000 litres) for anything up to 8 000 litres per day.[52] Customers using more than 8 000 litres per day pay R196.41 per 1 000 litres. Research from Stanford University suggests that 'increasing block price schedules provide strong incentives for consumers to conserve water'.[53]

Santa Fe, New Mexico began implementing tiered, or block, pricing more than a decade ago and has seen per capita water use drop by almost 30%.[54] Total municipal water withdrawals have decreased by about 20%, despite the city's population grew by more

# A Delicate Balance

continues from page 41

than 10%. The advantage of tiered pricing is that it 'offers a balance between fairness and efficiency', according to a 2014 study from the University of California, Riverside.[55] The study found that introducing tiered pricing in residential communities reduced demand by at least 18% in just over three years.[56]

Tiered pricing is beneficial because it does not rely on government regulation or forbid anyone from using additional water. The idea is that water meant for essential human consumption is as affordable as possible, while water used to maintain a swimming pool or lavish landscaping is relatively expensive. As Santa Fe's director of public utilities commented, 'for some people, a lawn is important, and if they want to spend their money on irrigation, they can'.[57]

Israel is another example of a country that has used tiered pricing to reflect scarcity.[58] That country also treats more than 80% of its wastewater and has employed a dynamic approach to water security that has allowed the country to move from continually overexploiting its renewable resources during the 1980–1990s to space where the National Water Authority is now able to reduce prices.[59] In South Africa, the DWS has been investigating an increase in tariffs but does not appear to be publically advocating for a national tiered pricing structure.[60]

Pricing water more responsibly should help create a culture of conservation, and avoid more onerous regulations such as the level 6b water restrictions currently in place in the Cape Town metro area.[61] The best way for other regions of South Africa to avoid having to deal with the harsh measures being implemented in the Western Cape is to start using water more consciously now.

There are also other demand reduction campaigns being implemented by DWS. In the Northern Cape, the department has issued 50 000 water-saving blocks for users to drop in their toilet cistern, to reduce the average flush by about 2 litres. The department hopes the 'drop-a-block' campaign will save over 100 000 litres of water per year.[62] DWS has also started the Clear Rivers Campaign, which calls on citizens to get involved in their communities and assist with river rehabilitation.[63] These are not national campaigns yet but could be built upon to encourage a more reflective conversation about water use in South Africa.

What is clear is that South Africa must implement a combination of strategies to restore balance to its national water system. The following section explores some alternate futures of water use in South Africa.

## SCENARIO ANALYSIS

South Africa's water sector hangs in the balance. As shown, stability is not out of reach. As other areas of the globe facing severe water stress have demonstrated, there are solutions available to cultivate a more secure water future for South Africa. These include implementing a combination of WCWDM strategies, increasing the amount of treated wastewater and using groundwater more frequently in areas where its longevity can be ensured.

This section will explore the likely future of South Africa's water sector and introduce some alternative scenarios. A first scenario (Agricultural Trade-offs) is intended to highlight the constraints that water scarcity can place on other development priorities. A second scenario is presented (Closing the Gap) to demonstrate how a comprehensive, robust response to the water challenges faced today could lead to a more secure water future in South Africa.

## AGRICULTURAL TRADE-OFFS

South Africa's NDP envisions a 'substantial investment in irrigation infrastructure' and loosely suggests a 50% increase over ten years as the first pillar of the country's national agriculture strategy.[64] South Africa currently has an estimated 1 670 000 ha equipped for irrigation in 2015, of which about 1 365 000 is irrigated.[65]

Both the NWRS2 and the Department of Agriculture, Forestry and Fisheries (DAFF) subsequently questioned if that increase was possible, or even desirable, given current water constraints.[66] The DAFF believes that 145 000 ha would be a more reasonable target, which it has established as its target for the national Agricultural Policy Action Plan.[67]

This scenario will explore some of the implications of increasing the amount of land under irrigation by roughly 145 000 ha by 2025 compared to the Current Path.

There are clear benefits to increasing irrigation. A well-executed expansion of irrigated land in South Africa could increase yields, decrease dependence on erratic rainfall and improve the overall resilience of the agricultural sector. However, an expansion of irrigation in South Africa will have to be conducted 'primarily through more efficient use of existing water resources'.[68] If South Africa

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# A Delicate Balance

continues from page 42

hopes to efficiently increase the amount of land under irrigation and get 'more crop per drop', it will have to exercise careful water management in the agricultural sector.[69]

Put bluntly, 'in conditions of increasing water shortage, further development of irrigated agriculture production is impossible without improving the methods of cultivation of crops, primarily irrigation technology'.[70]

If an expansion of irrigation is considered, it should be reserved for soils with a higher nutrient content to achieve the desired increase in yield. If this is accomplished, it should increase food production in the country and also leave more water for the municipal and industrial sectors.

In the Agricultural Trade-offs scenario, the land equipped for irrigation increases from its current (2017) level of 1 688 000 hectares to 1 910 000 by 2025 and then 1 987 000 by 2035. This leads to agricultural water demand to increase from 9.8 $km^3$ (in 2017) to 11.1 $km^3$ by 2035 (compared to the Current Path forecast of 10.4 $km^3$ in 2035). In the absence of other supply enhancement and demand reduction interventions, increasing the amount of land equipped for irrigation will be challenging, and will almost certainly have diminishing returns.

As South Africa's population continues to grow, incomes continue to rise, and the country seeks to expand its manufacturing sector, it will become increasingly difficult to allocate additional water to the agricultural sector.[71]

In the Agricultural Trade-offs scenario, municipal water demand still increases slightly, but only to 5.3 $km^3$ by 2035, compared to 5.6 $km^3$ in the Current Path. Crucially, municipal demand per capita is about 12% lower in the Agricultural Trade-offs scenario in 2035 than in 2015, compared to a 7% decrease in the Current Path. Industrial water demand is constrained as well, growing to just 1.77 km3 rather than 1.86 $km^3$ in the Current Path.

The agricultural sector will also need to be more efficient – water use per hectare of irrigated land in this scenario is 4% lower in 2035 than in 2015, against a 2% reduction in the Current Path. In this scenario, South Africa has less water to distribute to individuals, less water available to grow its manufacturing sector or increase the supply of thermoelectric power, and less water per hectare of irrigated land.

In other words, if the South African government hopes to achieve the irrigation target in the NDP, it will need to offset the additional withdrawals in the agricultural sector by either increasing supply through alternative sources (i.e. significant investments in treated wastewater, further groundwater extraction), or reducing demand through conservation measures or infrastructure improvements. It will very likely involve some aspects of both supply enhancement and demand reduction.

An essential consequence of the constraint that water scarcity places on agricultural production is that South Africa is forecast to become a significant net food importer by the late 2020s. This new future could have severe implications for food security, and make the country more vulnerable to droughts and other external shocks going forward.

Additional irrigation schemes will increase agricultural yields and resilience over the short run, but the amount of water devoted to agriculture is still restricted by the structural constraints of the water sector. Increasing the amount of land equipped for irrigation will mean that, over the long run, each hectare of farmland in South Africa receives less water than it otherwise would have without that additional irrigation. Moreover, as another land is irrigated and agricultural water demand increases, the municipal and industrial water sectors will be even more constrained than in the Current Path.

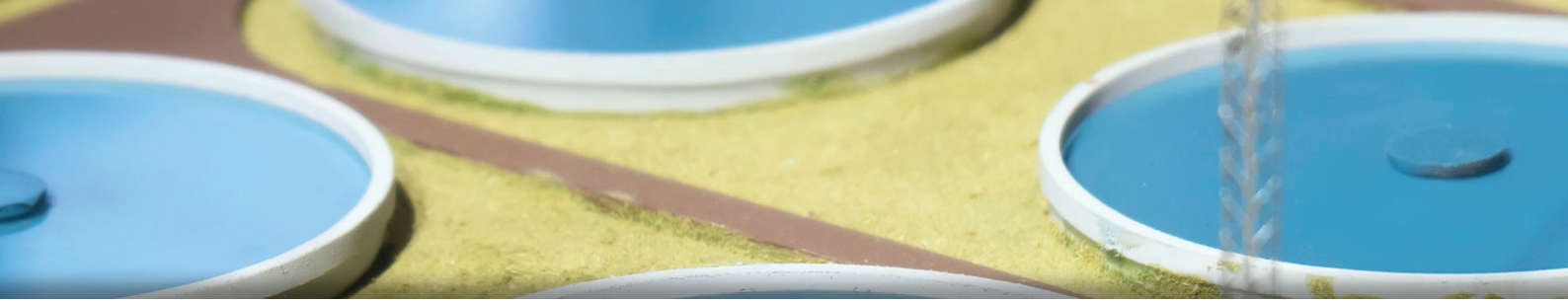
## CLOSING THE GAP

There are a plethora of policy options available to South Africa to reconcile supply and withdrawals in its water sector. The critical question is, what combination of penalties, incentives, investments and technologies should it embrace?

The Closing the Gap scenario is a future where water supply increases through higher levels of treated wastewater and renewable groundwater withdrawals. Irrigation does not expand at the same rate as in the Agricultural Trade-offs scenario, although it does increase in line with the Current Path. Water efficiency measures are put in place in the municipal, industrial and agriculture sectors. Renewable energy increases as a share of the national energy mix, leading to lower industrial water demand for coal-fired power plants. And finally, all of the planned supply interventions from all the reconciliation strategies are implemented on time.

## SUPPLY-SIDE INTERVENTIONS

There are various combinations of policies that could deliver a sustainable solution



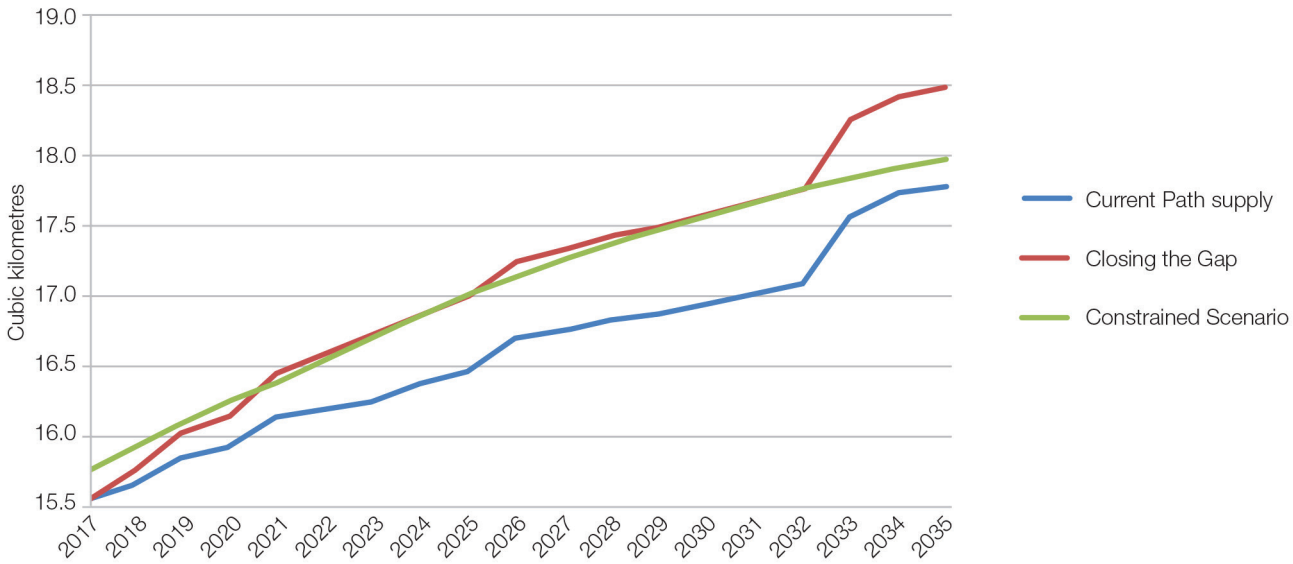



*Figure 6: Closing the Gap scenario (supply-side) relative to total supply on the Current Path and a revised withdrawals forecast.*

to South Africa. But, deciding which will ultimately provide the most significant return on investment requires detailed work at local and catchment level by experts with an intimate knowledge of the relevant conditions and constraints in their water systems.

At a national level, however, this research has pointed to broad areas that the South African government can focus on: increasing the amount of wastewater that is treated and reused, minimising non-revenue water or otherwise increasing efficiency in the municipal sector, increasing the intensity of groundwater use in areas where it is sustainable, and increasing the share of renewable sources in the national energy mix.

This section presents a scenario where the level of treated wastewater that is recycled through the system is increased by about 0.72 $km^3$ by 2035, and the amount of renewable groundwater extracted increases by about 0.3 $km^3$. This represents efforts well above and beyond what the government is currently planning.

In the Closing the Gap scenario, South Africa ambitiously implements the above recommendations. These interventions begin from 2018, occur over five years and are then maintained until the end of the forecast. Figure 6 shows that if South Africa can implement ambitious water policies, it is feasible to bring the water sector back into relative balance in a relatively short period. However, in this scenario, South Africa still toes the line of overexploitation for the next decade and a half, remaining vulnerable to drought and other external shocks.

Figure 6 gives the impression that it will be reasonably straightforward for South Africa to restore balance to its water sector, but it is worth restating the magnitude of the demand reduction implicit in this new forecast. Figure 6 represents an assumed reduction in demand of 1.2 $km^3$, compared to the estimates from Parched prospects 2.

So, if South Africa cannot quickly become more water-efficient – in the agricultural, municipal and industrial sectors – then the country's economic growth and human development prospects could be constrained by water scarcity.

In the Closing the Gap scenario, the agricultural sector becomes more water-efficient. Per hectare, water use is reduced by nearly 7% by 2035 relative to the Current Path. Likewise, the municipal water sector is more efficient, but less so than in the Current Path or in the Agricultural Trade-offs scenarios, owing to the supply-side increases.

Per capita, municipal water use only decreases by 2% between now and 2035 in this scenario, compared to 7% in the Current Path and 12% in the Agricultural Trade-offs scenario.

# A Delicate Balance

continues from page 45

These savings could be achieved in many ways. Reducing the level of non-revenue water by expanding the 'war on leaks' – along with other awareness campaigns – is an essential part of the solution.

WCWDM can also be implemented in the agricultural sector by employing more efficient irrigation technologies or growing less water-intensive crops. Perhaps most importantly, more conservative use of water must be encouraged through a tiered pricing structure, and other incentives for consumers to use more water-efficient appliances – tax rebates for purchasing water-efficient fixtures are a possible option.

However, even with a basket of interventions that effectively increase the available supply of water by more than 1 $km^3$ by 2035 – along with a reduction of 1.2 $km^3$ on the demand side – South Africa does not restore balance to its water sector until after 2030.

Together with the supply-side recommendations, this scenario represents a significant push from the South African government to stabilise the water sector and would necessarily involve a delicate combination of incentives and deterrents.

If the government begins to implement measures to enhance the supply and curtail demand aggressively, then it is on the edge of possible to restore sustainability to South Africa's water sector without resorting to extremely punitive restrictions.

But, if the government fails to respond to the situation, the country could be forced to endure a situation similar to the recent energy crisis, which nearly paralysed the economy.

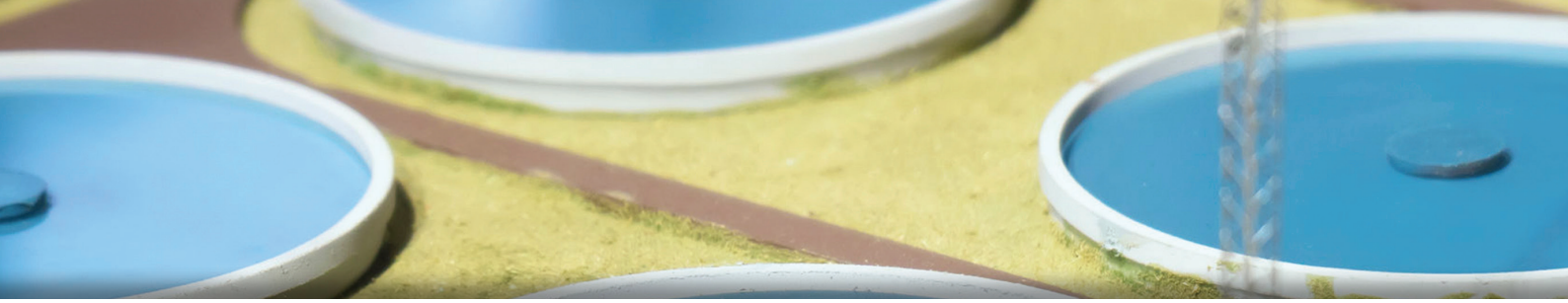
Based on the research presented in this report, these targets appear to be within the realm of possibility – at least in terms of South Africa's physical resources. Whether or not the South African government possesses the political will – or sufficient finances – to proactively address the problem, is an entirely separate question.

## CONCLUSION AND RECOMMENDATIONS

The general conclusion of this report is that it is possible for South Africa to reconcile its national-level water system by using available technologies and policies. This research indicates that the country can bring demand in line with available supply through strategies that incentivise efficiency (including tiered pricing), improve the quality of the country's water infrastructure (including wastewater treatment plants) and increase the amount of groundwater used. However, as new technologies (such as desalination and renewable energy) become increasingly affordable, there are other solutions beyond what has been outlined here that could help close the gap between supply and demand.

That said, South Africa cannot afford to delay the implementation of more aggressive water policies. To avoid a state of national panic – similar to that which occurred during the energy crisis of 2014–2015 – the government will have to act immediately. To align its water sector, South Africa must:

- Implement water conservation and demand reduction measures: The country must do more to improve the efficiency of water use. This can be done through a combination of infrastructure repairs (to address non- revenue water), new building codes, incentives to install water-efficient appliances and a tiered water-pricing structure. Policy measures should be supplemented with campaigns to raise awareness about high levels of per capita water use and the inherent value of water conservation in a water-scarce country.
- Increase the amount of wastewater that is treated and reused: About 60% of the country's wastewater is untreated, and a survey of 88 municipalities found that more than two-thirds of the wastewater treatment facilities examined did not meet minimum quality control standards. A failure to efficiently address wastewater treatment and reuse could have devastating consequences for people, the environment and the economy. Progress here will not only improve the quality of South Africa's water but also increase the supply.
- Increase groundwater extraction: Groundwater is likely an under-used resource in South Africa. Although there are no precise estimates of how much groundwater is available and where the DWS estimate suggests that there is potential to expand the amount of groundwater extracted significantly. This could be particularly useful for the agricultural sector, where nearly two-thirds of South Africa's water is used.
- Explore new technologies: This report stresses that there are available, affordable solutions to South Africa's water problems. However, it did not explore more advanced techniques in as much detail.
- Desalination: Currently, desalination technology is prohibitively expensive for South Africa, except in very large, coastal metropolitan areas such as Cape Town, Durban and Nelson Mandela Bay (desalination currently accounts for less



than 1% of South Africa's total water demand). As the cost of desalination decreases, it will likely become an increasingly viable option for these significant municipalities. However, desalination will not be able to address water scarcity in South Africa's inland areas and will have a limited impact on the agricultural sector, and so likely will only play a small part in South Africa's water future.

- Renewable energy: South Africa is almost entirely dependent on coal for its electricity needs. These thermoelectric power plants require large amounts of water for cooling and threaten to harm the country's water ecosystems further. Increasing the amount of energy generated from renewable sources will reduce industrial water demand, lower carbon emissions and minimise water contamination from industrial activity related to coal production.

In 2002, UNESCO adopted General Comment No. 15, which states that "the human right to water is indispensable for leading a life in human dignity. It is a prerequisite for the realisation of other human rights."[72]

As the forces of climate change, population growth, urbanisation and industrialisation collide in South Africa; it is vital that policymakers take aggressive measures to restore balance to the water sector. However, it is equally critical that those policies are implemented with the understanding that the country is still working to overcome decades of systemic oppression.

Finding the right balance between promoting general conservation among those who can afford it, while working on expanding access to clean water for those who do not currently have it, will be difficult. That said, it is hard to think of a more critical or worthy policy goal.

## REFERENCES

## ONLINE CONTENT

The first railway in London was opened between 1836 and 1838. This 6 km railway was on an elevated viaduct of 878 brick arches. This was the London and Greenwich Railway which ran from Tooley Street (near London Bridge) to London Street, Greenwich. This was the first railway built specifically for passengers. The railway was elevated to avoid many level crossings over the streets. It was intended that many of the arches could be rented out as workshops.

**BY** | DUDLEY BASSON


Extensive use was made of elevated railway lines supported on brick arches. The new owner of Network Rail's £1,5 billion commercial property portfolio has revealed plans to invest in reopening up to 430 unoccupied arches in London. Countrywide, there are some 4000 railway arches remaining. Two arches beneath Charing Cross station opened as The Arches in 1866. They were initially used as a billiard room and coffee room, and then a music hall. By May 1909 it had become

# Railways of London

the Arena, used for boxing matches and screening films. The Charing Cross Theatre founded in 1936, occupied several premises before locating to this site. This site was once a famous Victorian music hall, The Players Theatre.

The following link gives a fullscreen schematic map which includes the London Underground, DLR (Docklands Light Railway), Tramlink, London Overground, and Crossrail which is labelled TfL (Transport for London). The underground Crossrail section through Central London is labelled Elizabeth Line. The Emirates Air Line is not shown - this is a cableway link over the Thames linking Royal Victoria (DLR Line) to North Greenwich (Jubilee Line). The National Rail lines are not shown

# London Railways

continues from page 49


but the many links of the National Rail to the other services are indicated. The part of the Thameslink line running through London is not shown.

Route Map of London Underground

This high resolution map can be viewed in more detail by selecting a point with the cursor and clicking for zoom-in and zoom-out. The zoomed-in view can be moved using the slide bars at bottom and right.

Click here for a map of the National Rail lines.
Click here for the most amazing geographical railway map imaginable.

The gigantic highly detailed maps are viewed fullscreen and can be moved around with the cursor. Maps of many prominent cities in Europe and the USA are also available. The maps can also be zoomed in and out as required. This map shows details of all the tracks as well as the depots and sidings.

Passengers arriving at Heathrow have several choices for continuing their journey. Many may use taxi, bus or other road transport but many others will favour the convenient rail transport available.

The Heathrow Express, to become part of the new Crossrail service, provides a fast (comfortable but expensive) 15 minute service to Paddington, but the Piccadilly line provides an economical and convenient, albeit slower (1 hour), service to Central London and the rest of the Underground.

The Piccadilly line also links to the Eurostar at St Pancras where travellers can continue their journey through the Channel to Europe and on to the Paris *Gare du Nord* where they will find a *table d'hôte* of further transport choices. The Eurostar terminus was initially at Waterloo station but was transferred to St Pancras in 2007.

Click here for a ride on the Eurostar.

Click here for a trip from the Berlin Hauptbahnhoff to St Pancras.

**TABLE 1**

| NAME | PRONUNCIATION |
|---|---|
| Borough | Burra |
| Clapham | Clapim |
| Euston | You-stin |
| Greenwich | Grennitch |
| Gloucester | Gloster |
| Holborn | Ho-bin |
| Leicester | Lester |
| Marylebone | Mar-le-bin |
| Oxford | Oxfid |
| Southwark | Suth-irk |
| Thames | Tems |
| Tottenham | Tott-nim |
| Vauxhall | Vox-all |
| Welwyn | Wellen |

Foreign visitors to London may be confused by the pronunciation of some of the station names. Table 1 is provided as an approximate guide to pronunciation of some of the names. See the YouTube link for some audio instruction from one of the natives.

A station with a most daunting name can be found in North Wales on the island of Anglesey. This is commonly known as "Llanfair pg" as an abbreviation of: Llanfairpwllgwyngyllgogerychwyrn-drobwllllantysiliogogogoch.

This name appears to be a tourist curiosity as it has no heritage significance.


*The TfL Roundels*

Llanfair (St Mary's Church) is pronounced 'ghlaan-vire'.

## TRANSPORT FOR LONDON (TfL)

TfL is a local government body, established on 3 July 2000, responsible for the transport system in Greater London. It gained most of its functions from its predecessor, London Regional Transport in 2000.

TfL has responsibility for London's network of principal road routes, for various rail networks including the London Underground, London Overground, DLR and TfL Rail. It also has responsibility for London's trams, buses and taxis, cycling provision and river services.

TfL is also responsible, jointly with the national Department for Transport for commissioning the construction of the new Crossrail line, and will be responsible for franchising its operation once completed.

TfL commissioned a survey in 2013 which showed that 15% of women using public transport in London had been the subject of some form of unwanted sexual behaviour but that 90% of incidents were not reported to the police. In an effort to reduce sexual offences and increase reporting, TfL, in conjunction with the British Transport Police, Metropolitan Police Service, and City of London Police, launched Project Guardian. This project has met with much success and may possibly be introduced to other cities.

London has highly sophisticated ticketing systems to cope with the huge streams of travellers, particularly those entering and leaving the Underground stations. Most travellers in London use the blue Oyster card. This is a contactless electronic smart card which comes fully charged with credit and can be used on the Underground, buses, DLR, river bus service, London Overground and most National Rail services in London. Passengers frequently place their Oyster cards at the bottom of handbags or in wallets so that they can quickly pass through the gates without removing the cards. On trips served at both ends by both Underground and National Rail, passengers can pay using the Oyster card and travel on the more expensive and comfortable National Rail train. The Oyster cards must be presented on entering and on leaving the rail stations. For bus and river travel the cards must be presented only once.

Visitors to London may prefer to use the multi-coloured Visitor Oyster Cards which must be purchased on-line before arriving in London. This will provided cheaper fares than a Travelcard and also has daily limit capping for unlimited travel. The old familiar Travelcards are still alive and well. These are issued for a particular number of days and for specified travel zones. These cards are also capped for unlimited travel so that they may be preferred by passengers who wish to make many trips in a specified number of days. For a single day of travel it may well be cheaper to use an Oyster card. Travelcards can also be loaded onto Oystercards. The Travelcards must be passed through the card readers at the passenger gates. Passengers can also use contactless smart cards issued by local banks but this will not be useful to most visitors.


## LONDON UNDERGROUND

The London Underground had its first day on 10 January 1863 carrying 38 000 passengers. The first line constructed was the Metropolitan, running between

# London Railways

continues from page 51


Paddington and Farringdon Street. The trains were initially hauled by steam locomotives. The use of fireless steam locomotives was tried but found to be unsatisfactory.

The Thames Tunnel from Rotherhithe to Wapping, constructed by Sir Mark Isambard Brunel and his son Isambard Kingdom Brunel, had opened in 1843. This was an astonishing achievement which would be followed by some 25 more Thames tunnels over the years. At the time this was extremely difficult and dangerous work. Brunel used a tunnelling shield of his own design for excavating the tunnel.
This was the first ever tunnel constructed beneath a navigable river. The Brunel tunnel was intended for horse drawn traffic and pedestrians but would be repurposed several times and in 1869 used for rail traffic including the London Underground and later becoming part of the London Overground railway.

The first underground lines were of shallow depth cut and cover construction and are known as the sub-surface lines.

In 1870 Tower Subway opened briefly using a cable-hauled carriage before converting to pedestrian use. This was constructed using a circular tunnelling shield developed by P W Barlow and J H Greathead (South African) and lined with segmental cast iron rings. This short tunnel under the Thames successfully demonstrated new tunnelling techniques that would be used to construct most of the subsequent underground lines in London.

Click here to see the origins and growth of the London Underground.

**TABLE 2**

| UNDERGROUND LINE | FIRST OPERATED | STATIONS | LENGTH KM | ANNUAL PASSENGER TRIPS IN MILLIONS |
|---|---|---|---|---|
| Metropolitan | 1863 | 34 | 66,7 | 66,78 |
| District | 1868 | 60 | 64,0 | 208,32 |
| Jubilee | 1879 | 27 | 36,2 | 213,55 |
| Circle | 1884 | 36 | 27,2 | 114,61 |
| Northern | 1890 | 50 | 58,0 | 252,31 |
| Waterloo & City | 1898 | 2 | 2,4 | 15,89 |
| Central | 1900 | 49 | 74,0 | 260,92 |
| Piccadilly | 1906 | 53 | 71,0 | 210,17 |
| Bakerloo | 1906 | 25 | 23,2 | 111,12 |
| Victoria | 1968 | 16 | 21,0 | 199,98 |
| Hammersmith & City | 1988 | 29 | 25,5 | 114,61 |

Click here to watch a video clip of an Underground steam locomotive commemorating 150 years of passenger service.

Click here to see more information on steam on the Underground see:

The London Underground currently has eleven lines serving 270 stations, colour coded as shown. The lines have a total length of 402 km (Crossrail not included). The Elizabeth line is the underground portion of the Crossrail in Central London. It has been assigned the colour purple but this may be changed to lime green. It is not part of the Underground Network. It shares however several of the Underground stations (To which major construction has been added) but has its own tunnels, tracks and platforms.

This fairly recent table (Table 2) gives an indication of the huge extent and usage of the London Underground. The usage pattern will see some change when the Elizabeth Line becomes fully operational.

The Elizabeth Line is expected to carry some 200 million annual passenger trips.

In Table 3, the Underground lines are the first eleven in the left column. The TfL line includes the Elizabeth line.

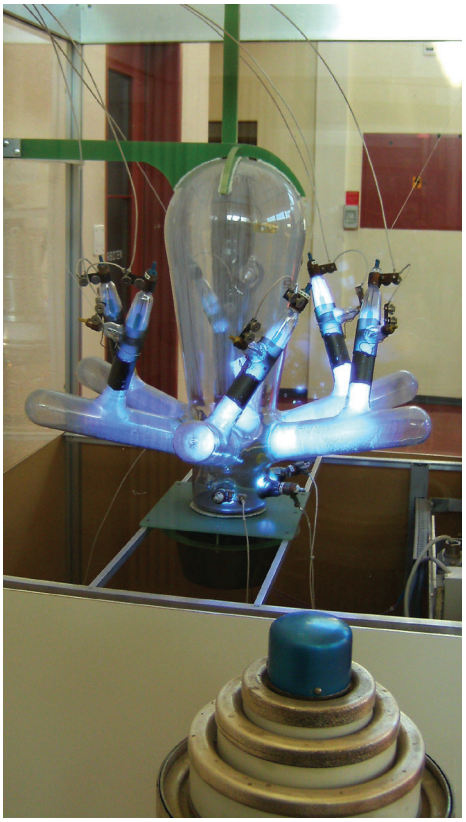
There are 32 km of cut-and-cover tunnels and 150 km of tube tunnels, the other 55 per cent of the system running above ground.

The London Underground lines are electrified using a four rail DC system. A conductor rail between the running rails is energised at -210 V and a conductor rail outside the track at 420 V giving a potential difference of 630 V. On the sections of line shared with main line DC trains, the centre rail is bonded to the running rails, as the return from National Rail DC trains is through the wheels.

**London Railways including Underground, TfL, DLR and National Rail**

| | |
|---|---|
| Bakerloo | Chiltern Railways |
| Central | c2c |
| Circle | Gatwick Express |
| District | Great Northern |
| Hammersmith & City | Great Western Railway |
| Jubilee | Greater Anglia |
| Metropolitan | Heathrow Express |
| Northern | London Northwestern |
| Piccadilly | South Western Railway |
| Victoria | Southeastern |
| Waterloo & City | Southeastern high speed |
| DLR | Southern |
| London Overground | Thameslink |
| London Trams | |
| TfL Rail | |
| Emirates Air Line | |

*Table 3*



*Three-phase mercury arc rectifier*

Railway electrification in Great Britain began during the late 19th century. A range of voltages have been used, employing both overhead lines and conductor rails. The two most common systems are 25 kV single phase AC using overhead lines, and the 750 V DC third rail system used in southeast England and on Merseyrail.

In 2006, 40% - 4,928 km of the British Rail network was electrified, and 60% of all rail journeys were by electric traction.

According to Network Rail, 64% of the electrified network uses the 25 kV AC overhead system, and 36% uses the 660/750 V DC third-rail system.

Electrification began in the 1890c. At the time, DC motors were the only form of electrical traction with variable speed operation available. DC series wound motors were the best choice for traction purposes, as they can be controlled by voltage, and have an almost ideal torque vs speed characteristic. Series wound DC motors do not have a definite running speed and can self-destruct from over speed if allowed to run without being attached to a load.

AC squirrel cage induction motors supplied with fixed frequency power are essentially single speed motors. To provide DC power it was necessary to rectify the AC to DC using rotary converters (motor-generator sets), as it was impractical to provide low voltage DC over great distances. The rotary converters were superseded by three phase mercury-arc rectifiers.

By the 1920s, both the glass-bulb and steel-tank types of mercury-vapour rectifier were Three phase mercury arc rectifier sufficiently developed to be used in railway service, first for battery charging, then as supplements to rotary sets, and finally as main power rectifiers. Throughout the 1930s, both the glass-bulb type, and the multianode steel-tank rectifier were installed in automatic substations, remotely controlled.

Mercury arc rectifiers were superseded by silicon semiconductor rectifiers and high power thyristor circuits in the mid-1970s.

AC induction motors with variable speed control and 25 kV 50/60 Hz supply have become a de facto international standard for new railway traction.

# London Railways

continues from page 53


Click here for a look at Brunel's vision for Paddington station.

Click here to see the corner cube reflectors at Paddington.

Watch a video of abandoned Underground stations:

Click here for a showcase of underground maps. Click on favourites and then on image for full screen and click again for zoom in and out.

The Waterloo & City line is a shuttle line that runs between Waterloo and Bank, on opposite sides of the Thames, with no intermediate stops. At 2,37 km, this is the Underground's shortest line. Its primary traffic consists of commuters from south-west London, Surrey and Hampshire arriving at the Waterloo main line station and travelling forward to the City of London's financial district. For this reason the line does not normally operate on Sundays.

## CROSSRAIL

The Crossrail is a £17,6 billion (latest estimate) project which will provide a huge increase in rail passenger capacity and also relieve pressure on the London Underground. During construction this was the largest engineering construction project anywhere in Europe or UK. This will have links to several Underground stations on most of the lines as well as the DLR and National Rail.

The Crossrail trainsets comprise 9 coaches with a total length of 205 m requiring platforms longer than those of the Underground and the trains are also incompatible with the Underground electrification.

The Class 345 is a Bombardier Aventra design being manufactured for London's Crossrail. Seventy trainsets are being manufactured at a cost of over £1 billion, with each train able to reach 140 km/h and carry 1500 passengers. The contract was awarded to Bombardier Transportation in February 2014 and the first train entered service on 22 June 2017. Initial deliveries are of seven carriage sets, which will be extended to nine carriage sets at a later date.

The central underground section of Crossrail passing under central London, known as the Elizabeth Line, will have trains of nine carriages and a frequency of 24 trains per hour.

Click here to see Crossrail maps.

See the regional and route maps for the full 117 km route from Shenfield to Reading with all links to the Underground, National Rail and DLR indicated.
Farringdon Station

Elizabeth Line

Tottenham Court open day

An engineering article in the July 2015 issue of **watt**now gives details of the 400 kV bulk supply points from the grid and the 25 kV autotransformer traction distribution system.

The article also describes how the millions of tons of excavated material have been used to rehabilitate a wildlife sanctuary in the Thames estuary.

Unlike the Underground, the Crossrail trains use single phase 25 kV AC power, supplied from overhead rail in the tunnels or overhead catenary suspended wire when above ground. Passengers changing from Underground to the Crossrail Elizabeth Line will quite likely not notice that these are two distinct railway systems. This is a similar situation to that found in Paris. Passengers do not normally notice that the Metro and RER (Réseau Express Régional) are two distinct systems.

Eight 1000 ton tunnel boring machines were used for three years to bore 6,2 m diameter twin tunnels with a combined length of 42 km, excavating 3,4 million tons of earth.

The tunnels weave their way between existing underground lines, sewers, utility tunnels and building foundations from station to station at depths of up to 42m.

Watch this excellent video on the tunnel boring machines can be seen at:

Extraordinary archaeological finds have been made during the Crossrail excavations.

Watch this video clip of the archaeological discovery effort.


*Fragments of a chamber pot discovered during excavations*

During construction, Crossrail undertook one of the most extensive archaeological programmes in the UK. It presented an opportunity to preserve finds for archaeological study and inform wide audiences about the rich history of London.

Since construction of the Elizabeth line began in 2009, over 100 archaeologists have found tens of thousands of items from 40 sites, spanning 55 million years of London's history and pre-history. The new railway runs east to west through some of the capital's most significant historical areas.
The public programme culminated in a final exhibition in 2017 that showcased 500 of the most exciting discoveries on the project. Delivered in partnership with the Museum of London Docklands, the "Tunnel: the archaeology of Crossrail" exhibition received 96,750 visitors – the highest ever at the venue – and a further 7,324 event participants.

## LONDON OVERGROUND

The London Overground is an amalgamation of several old lines and serves a total of 112 stations.

Watch this two-part fascinating video clip of the London Overground and father and son Brunel's famous tunnel under the Thames.

## DOCKLANDS LIGHT RAILWAY

The Docklands Light Railway is an automated light metro system serving the redeveloped Docklands area of East London. The service began operations in 1987 and serves in all 45 stations.

Click here to see the map for details of the numerous links to the London Underground, Crossrail and National Rail. Watch the DLR in action in the video clip

Being fully automated, the DLR trains are driverless and have passenger seats at the heads of the trains, which allow youthful passengers to imagine that they are driving.

## TRAMLINK

London's tram network was introduced to South London in 2000. The Tramlink runs from Wimbledon through Croydon to Beckenham, where it has proven a popular mode of transport. Ticketing is done as part of the bus system.

Click here for the Tramlink map with links to the London Underground and National Rail indicated.

# London Railways

continues from page 55

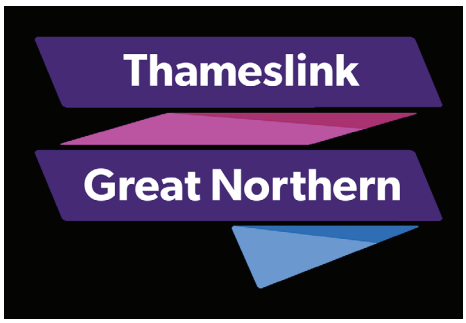

Click here for Tramlink travel information.

The Tramlink services are disability friendly with step-free access and free of charge travel for wheelchair users.

## EMIRATES AIR LINE

This is not a railway - it is an aerial cableway crossing the Thames and linking Royal Victoria (DLR Line) to North Greenwich (Jubilee Line). This service was opened on 28 June 2012 and is operated by TfL. In addition to transport across the river, the service advertises a unique view of London.

Watch the video of the Emirates Air Line.




## THAMESLINK

This is a major railway system going north as far as Peterborough and connecting with Welwyn Garden City and Cambridge. Going south it reaches Gatwick airport and Brighton. The service serves 115 stations. This 24-hour service is powered by 25 kV 50 Hz single phase AC overhead line or 750 V DC third rail. The service runs on the Southern Region third rail network from Farringdon southwards and on overhead line northwards to Bedford. The changeover is made whilst stationary at Farringdon when heading southbound, and at City Thameslink when heading northbound.

Passing through London, the service connects with several Underground, Crossrail and DLR stations, notably St Pancras International. The Thameslink is not usually shown on London transport maps. The service operates a fleet of 115 trainsets.

Click here to see a map of the Thameslink routes.

For a comparison of times for the Tube and Thameslink doing the same trip, watch.

Click here to watch the Thameslink trains at Elephant and Castle.

## POST OFFICE RAILWAY

This underground railway was operated by the Post Office from 1927 to 2003.

The line ran from Paddington Head District Sorting Office in the west to the Eastern Head District Sorting Office at Whitechapel in the east, a distance of 10,5 km. It had eight stations, the largest of which was underneath Mount Pleasant, but by 2003 only three stations remained in use due to the other sorting offices above the other stations being relocated.

The main line has a single 2,7 m diameter tube with two tracks. Just before stations, tunnels diverge into two single-track 2,1 m diameter tunnels leading to two parallel 7,6 m diameter station tunnels. The main tube is at a depth of around 21 m. Stations are at a much shallower depth, with a 1-in-20 gradient into the stations. The gradients assist in slowing the trains when approaching stations, and accelerating them away. There is also less distance to lift mail from the stations to the surface. At Oxford Circus the tunnel runs close to the Bakerloo line tunnel of the London Underground.

This was a narrow gauge (610mm) driverless railway powered by a 440 V DC third rail.

Click here for more information on the large number of heritage and private railways, including the Welsh narrow gauge railway.

## TFL DATA TRACKING

A plan by Transport for London to collect data from the network's Wi-Fi users about their movements across the city's transport system has underscored the importance of mass data tracking regulation, according to a cybersecurity expert.

Announced in May 2019, the project will see depersonalised data collected from users' Wi-Fi connections on the network from 8 July. TfL has said that individual passengers will not be identified from the data collected.

It is hoped that the TfL data tracking plans will enable improvements to the network, including providing insights into areas with overcrowding that users can then avoid.

TfL chief data officer Lauren Sager Weinstein declared:
*"The benefits this new depersonalised dataset could unlock across our network - from providing passengers with better alerts about overcrowding, to helping station staff have a better understanding of the network in near real time - are enormous."*

TfL is working with the Information Commissioner's Office to ensure it complies with data protection laws, including GDPR (General Data Protection Regulation), during the project. However, this does indicate how important these types of laws

are in ensuring that such projects protect the privacy of users.

Paul Norris, senior systems engineer, at Tripwire declared:

*"It is important that these mass-collections of data are monitored and regulated. There is nothing inherently risky in collecting information that will help improve the logistics of operations, but passengers should be informed that a certain type of data will be recorded and asked whether they wish to opt out. This will likely happen through an additional disclaimer to which users will have to agree before they can connect to the public Wi-Fi."*

As more options for connections become available, there are going to be a growing number of opportunities for projects like the TfL data tracking plans - and while current regulations are helping to protect users, Norris argues that companies will need to ensure they place consumer protection at the core of any future efforts.

*"How the information is stored and who can access it is also something that needs addressing: as our ability to monitor one's every step increases, it is essential that individual privacy remains at the forefront of any organisation's priorities.*

*To edge on safety and safeguard their privacy, users should consider using a VPN (Virtual Private Network) anytime they access a public network."*

It is a sign of the times, that the use of cell phones and public Wi-Fi has become so ubiquitous that this can be used for capturing statistics of public movement.

# CPD course calendar

## VENUE: SAIEE HOUSE 18A GILL STREET OBSERVATORY

| AUGUST 2019 | |
|---|---|
| 5-6 | Photovoltaic Solar Systems |
| 13-14 | SANS 10142-1. 2017 Edition 2 & OHS Act |
| 15-16 | Earthing & Lightning Protection *(Blue Lagoon Hotel & Conference Centre, East London)* |
| 20-22 | A Practical Introduction To Rotating Electrical Machines |
| 21-22 | Arc Flash Workshop |
| 21-22 | Fundamentals Of Power Distribution |
| 27-28 | Internet Of Things (Iot) Standards And Applications |
| 28-29 | Writing Good Technical Specifications |
| 29-30 | FIDIC Course |
| | |
| **SEPTEMBER** | |
| 3-4 | Network Frequency Control With Increasing Renewable Power Plants |
| 10-11 | Practice of Management for Engineers |
| 10-12 | Substation Design and Equipment Selection |
| 12-13 | Fundamentals of Long Term Evoluton (LTE) Mobile Communication |
| 17-18 | Fundamentals of Developing Renewable Energy Plants |
| 17-20 | Advanced Microprocessor Based Power System Protection |
| 19-20 | Cable Jointing, Termination and Testing |
| 26-27 | High Voltage Testing and Measurement |
| 27 | Road to Registration for Engineering Candidates |
| | |
| **OCTOBER** | |
| 8-11 | Project Management For Professionals |
| 9-10 | Design Of Economical Earthing Systems For Utility Electrical Installations |
| 15-16 | Photovoltaic Solar Systems |
| 17-18 | SDN/NFV Standards And Applications |
| 22-23 | Incident Investigaion And Management (Incl. Root Cause Analysis) |
| 23-25 | Fundamentals Of Medium Voltage Protection |
| 24-25 | LV, MV & HV Switchgear Operation, Safety, Maintenance & Management |

** PLEASE NOTE: The above courses are only confirmed on condition that a minimum number of registration are received. The course dates are subject to change. The SAIEE reserves the right to cancel any course.*

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# Our Expert Answers

*Information provided by Zest WEG Group*

## QUESTION ONE

Can low voltage electric motors be stored for prolonged periods of time?

## ANSWER ONE

Yes, low voltage motors can be stored for long periods of time, but the following needs to be considered.

The motors need to be stored in a location where these are protected from the elements. This is because the storage ingress protection (IP) rating is not the same as the operational IP rating, which means motors need to be stored where they will not be subjected to rain or excessive dust.

Motors should be protected against any source of vibration. As the rotors are stationary during storage, vibration can be a major cause of premature bearing failure during operation. The lubricant does not do much during storage, and the rolling elements have direct contact with the bearing races. If vibration is present, the rolling element will make micro indentations in the races, the rolling elements can get flat spots, and brinelling of the bearing could occur. This brinelling will worsen during operation and will ultimately lead to bearing failure.

It is also recommended that the shaft of each motor be rotated monthly by hand, to evenly redistribute the lubricant in the bearings. At least five revolutions will be required, and the shaft must be stopped in a different position every month. Small marks can be made on the end shield in line with the key to keep a record of each position. If the motor is fitted with a shaft locking device, this locking device will need to be removed prior to turning the shaft, and installed afterwards.

Vertical motors may be stored in the vertical or horizontal position.

If motors are stored for longer than six months and have open bearings, these will need to be re lubricated according to the original equipment manufacturer's specifications. If stored for more than two years, the bearings will need to be opened, washed, inspected and re lubricated, or simply be replaced.

## QUESTION TWO

Should Variable Speed Drive (VSD) rated motors have insulated bearings?

## ANSWER TWO

As a norm, motors from frame size IEC 315 (NEMA 445/7) should have insulation on the non-drive end bearing. This could be either an insulated bearing or an insulated end shield. An earthing brush must be installed on the drive end of the motor to create a path of low resistance for any stray voltages induced in the rotor shaft. This will facilitate the flow to earth through the brush and not through the bearing, minimising chances of electrical pitting and premature failure.

## QUESTION THREE

What on-site inspections, assessments or repairs can be done on electric motors?

## ANSWER THREE

The design of low voltage (LV) motors is relatively simple, however it is always recommended that any repair work be done by qualified field service technicians.

It is possible to replace the cooling fan and cowl, should this become damaged, and bearings can also be replaced with relative ease. Should the temperature detector fails, this can also normally be changed on site.

On high voltage (HV) motors there are also a number of repairs that can be done on site. This includes but is not limited to:

- Bearing inspection on sleeve bearings, where there is suspicion of bearing wear, contaminants or where high vibration or temperatures have been detected on the bearings.
- Bearing replacement where the bearings are damaged or worn
- External fan repairs and/or fan cowl replacement
- Terminal box replacement due to damage on site
- Terminal connection repairs where there were hot connections or where physical damage has been done to the terminal block
- Sealing repairs where there is dust ingress into the motor
- Oil leak repairs on oil lubricated bearings, including replacement of labyrinth seals
- Rotor lead replacement on slip ring motors
- Slip ring replacement on slip ring motors
- Brush box and brush replacement on slipring motors
- Repairs to the brush lifting and short-circuiting gear of slip ring motors, where fitted.

## QUESTION FOUR

How does brush lifting short circuiting on a slip ring motor work?

## ANSWER FOUR

A slip ring motor fitted with brush lifting gear has the benefits of both a wound rotor as well as a squirrel cage rotor.

On start-up, the motor uses the wound rotor for the higher torque required, for instance to turn a mill. The rotor is connected to a liquid resistance starter (LRS) through brushes that run on the slip rings. This LRS, connected to the rotor circuit, increases the rotor resistance, giving the motor a high starting torque. When the motor is started, the electrodes mounted on dippers inside the LRS start to lower into the electrolyte reducing the resistance in the circuit as it moves down towards the fixed electrodes.

Once the movable electrodes reach their lowest position with the lowest rotor circuit resistance, a limit switch will be energised, sending a signal to the brush lifting gear to engage.

Firstly, the slip rings will be shorted out by a shorting hub fitted with female contacts, engaging into the male contacts fitted on the slip ring. Once the slip rings are shorted out, the mechanism will continue and arms mounted on a ring around the slip rings will be activated to lift the brushes off the slip rings. The motor will then continue to operate as a squirrel cage motor, with zero brush dusting and brush wear during operation.

Only when the motor is stopped, will the brushes lower to the slip rings again, and the shorting hub will disengage.

The motor will then be in the ready-to-start condition. wn

# July in History

July is the seventh month of the year in the Julian and Gregorian Calendars and the fourth of seven months to have a length of 31 days. It was named by the Roman Senate in honour of Roman general Julius Caesar, it being the month of his birth

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

## 1 JULY

2000 Trillian, a proprietary multi-protocol instant messaging application was launched. The program was named after Trillian, a fictional character in The Hitchhiker's Guide to the Galaxy by Douglas Adams.

## 2 JULY

1947 A rancher discovered unidentifiable debris in his sheep pasture outside Roswell, New Mexico, USA. Although officials from the local Air Force base stated that it was a crashed weather balloon, many people believed it was the remains of an extra-terrestrial flying saucer. Nearly 50 years after the story of the mysterious debris broke, the US military issued a report linking the incident to a top-secret atomic espionage project called Project Mogul.

## 3 JULY

1844 The day that great auk (Pinguinus impennis), became extinct. Although similar in appearance to the birds now known as penguins, they are not related.

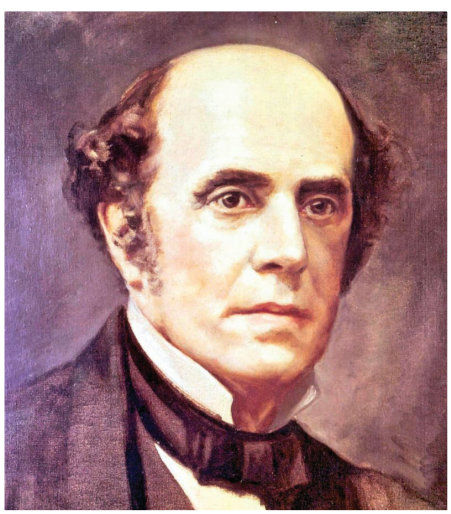
## 4 JULY

1837 The Grand Junction Railway, the world's first long-distance railway, opened. It ran between Birmingham and Liverpool, in the UK between 4 July 1837 and 1846, covering a distance of 132km.

## 5 JULY

1841 Thomas Cook (founder of Thomas Cook Travel Agency) lead his first excursion of around 500 people, who paid one shilling each for a return train journey. They travelled from Leicester Campbell Street railway station to a teetotal rally in Loughborough, eleven miles away.


*"It's not an electrical problem. Something's wrong with your corporate DNA!"*



## 6 JULY

1887 Wimbledon Women's Tennis: Lottie Dod became the youngest ever Wimbledon champion (15 years, 285 days); defending champion beats Blanche Bingley 6-2, 6-0. This year, 2019, Cori Gauff is the youngest player ever to qualify for the main draw for Wimbledon.

## 7 JULY

1928 Sliced bread was sold for the first time by the Chillicothe Baking Company, Missouri, USA, using the machine invented by Otto Frederick Rohwedder. It was described as the most significant step forward in the baking industry since bread was wrapped.

## 8 JULY

2018 The first four boys were rescued, after being trapped for 16 days, from Tham Luang cave, Thailand, by Thai and international rescue teams.

## 9 JULY

1877 The Bell Telephone Company became a joint stock company with a total of 5000 shares being issued to: Gardiner Greene Hubbard (trustee and president) (Alexander Graham Bell's father-in-law), Gertrude Hubbard (wife of Gardiner Hubbard), Charles Eustis Hubbard (the brother or nephew of Gardiner Hubbard), Alexander Graham Bell (inventor of the telephone and the company's 'Chief Electrician'), Thomas Sanders (financier and treasurer), Thomas Watson (head of operations, and its first full-time employee).

## 10 JULY

1962 Telstar 1, a communications satellite, launched by NASA was the satellite that allowed the first live broadcast of television images between the United States and Europe. It remained active for only 7 months, much shorter service life than today's artificial satellites. Although it no longer works, it is still in Earth orbit.

## 11 JULY

1976 The last slide rule was manufactured and presented to the Smithsonian Institution (USA). For many years it had been the most common method of performing mathematical calculations and became obsolete with the invention of the computer and its smaller, hand-held sibling, the calculator.

## 12 JULY

1949 At an IBM sales meeting, Thomas J. Watson Jr. (at the time Executive Vice-President of IBM) predicted that electronics would replace all moving parts in machines within ten years. Watson's visionary ideas of where the fledgeling computer industry might go, helped lead his company to dominance in the production of all varieties of computers, from workstations to personal computers.

## 13 JULY

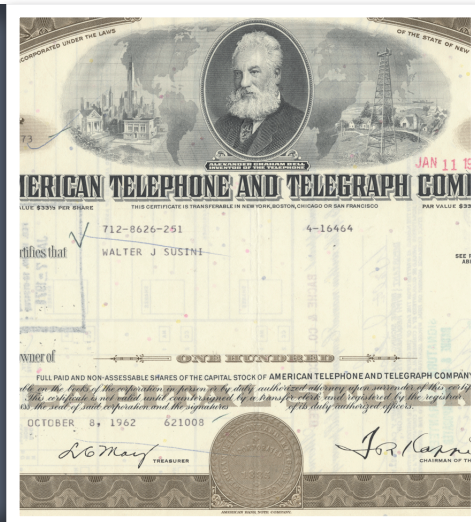
2018 Deputy President of the Republic of South Africa, David Mabuza, inaugurated the country's 64-array MeerKAT radio telescope.

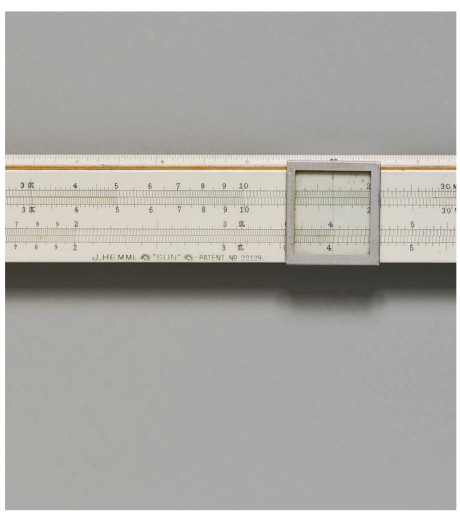
## 14 JULY

2009 The iTunes Music Store application downloads reached 1.5 billion.

## 15 JULY

1983 Nintendo releases their Famicom system, short for "Family Computer," in Japan. The Famicom would be slightly modified with a copy protection system, a redesigned chassis, a front loading cartridge mechanism, and released in North America just over two years later as the Nintendo Entertainment System (NES).



# July in History

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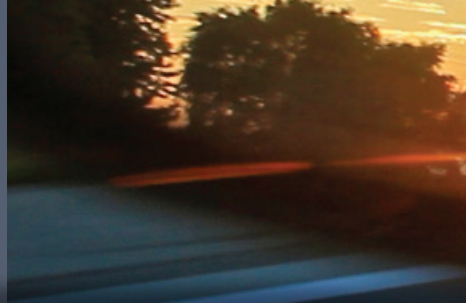


## 16 JULY

1439 Kissing was banned in England (to stop the Black Death from spreading).

## 17 JULY

1997 A programming error temporarily threw the Internet into disarray in a preview of the difficulties that inevitably accompany a world dependent on e-mail, the World Wide Web, and other electronic communications.

At about 2:30 a.m. Eastern Daylight Time, a computer operator in Virginia, USA, ignored alarms on the computer that updated Internet address information, which led to problems on several other machines with similar responsibilities. This corruption meant most Internet addresses could not be accessed and resulting in millions of unsent e-mail messages.

## 18 JULY

2015 Scientists at CERN's (The European Organization for Nuclear Research) Large Hadron Collider announced the discovery of the pentaquark. A pentaquark is a subatomic particle consisting of four quarks and one antiquark bound together.

## 19 JULY

1983 Michael W. Vannier (Mallinckrodt Institute of Radiology, St. Louis) and his co-workers J. Marsh (Cleft Palate and Craniofacial Deformities Institute, St. Louis Children's Hospital) and J. Warren (McDonnell Aircraft Company) published the first three-dimensional reconstruction of a human head using single computed tomography (CT) slices. Computer-aided aircraft design techniques had been adapted to make the cranial imaging possible. Since then, CT imaging has become a cornerstone of the medical profession.

## 20 JULY

2003 In New Delhi, India, elephants used for commercial work at night began wearing reflectors to avoid being hit by cars.

## 21 JULY

2011 STS-135 (ISS assembly flight ULF7), the 135th and final mission of the American Space Shuttle program, landed. It used the orbiter Atlantis and hardware initially processed for the STS-335 contingency mission, which was not flown. The mission's primary cargo was the Multi-Purpose Logistics Module (MPLM) Raffaello and a Lightweight Multi-Purpose Carrier (LMC), which were delivered to the International Space Station (ISS).

## 22 JULY

2009 The longest total solar eclipse of the 21st century, which lasted 6 minutes and 39 seconds, occurred over parts of Asia and the Pacific Ocean.


## 23 JULY

1995 Comet Hale–Bopp was discovered. It became visible to the naked eye on Earth nearly a year later for a record eighteen months.

## 24 JULY

1987 Hulda Crooks, an American mountaineer, at 91 years of age, climbed Mt. Fuji. Crooks became the oldest person to climb Japan's highest peak.

## 25 JULY

1990 Microsoft Corp. reported revenues of more than $1 billion for its fiscal year 1990, but its spectacular growth didn't stop there. Founded in 1975 by Bill Gates and Paul Allen, Microsoft has continued its dominance of the computer industry since then.

## 26 JULY

2016 After more than 16 months and approximately 42,000-kilometre Solar Impulse 2 became the first solar-powered aircraft to circumnavigate the Earth.

## 27 JULY

1940 Warner Brothers' character Bugs Bunny was introduced in the animated short movie, A Wild Hare.

## 28 JULY

1964 Ranger 7, the first US space probe, was launched. Three days later it sent back a series of pictures as it impacted into the Moon's surface. It transmitted over 4,300 photographs during its final 17 minutes of flight.

## 29 JULY

2010 Malawi adopted a new national flag, replacing the previous flag that had been flown since 1964.

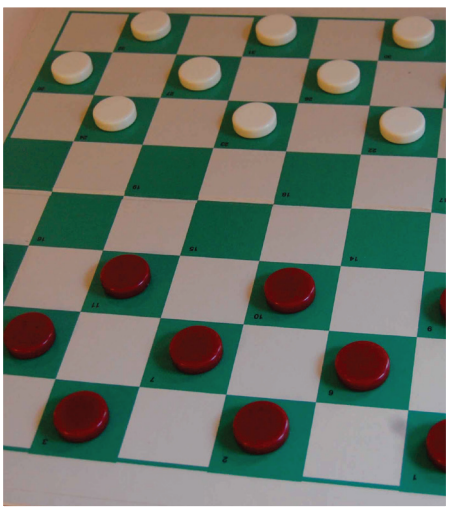
## 30 JULY

1951 The first draughts (checkers) computer program was run on the National Physical Laboratory's (London, England) Pilot ACE (Automatic Computing Engine).

It was written by Christopher Strachey (a British computer scientist) during his spare time. The Pilot ACE was one of the earliest stored-program computers and was designed by Alan Turing.

## 31 JULY

1928 Hollywood film studio, Metro-Goldwyn-Mayer's (MGM) Leo, the lion found his voice when he roared while introducing MGM's first talking picture, "White Shadows on the South Seas." Although MGM has referred to all of the lions used in their trademark as "Leo the Lion", only the current lion, in use since 1957 (a total of 62 years), was named "Leo". wn



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### DEMONSTRATION **VIDEO**

https://www.youtube.com/watch?v=EBXVIsVMt5M

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http://www.cybathlon.ethz.ch/cybathlon-2020/participating-teams/arm-prosthesis-teams.html#touchhand

### MORE **DETAILS**

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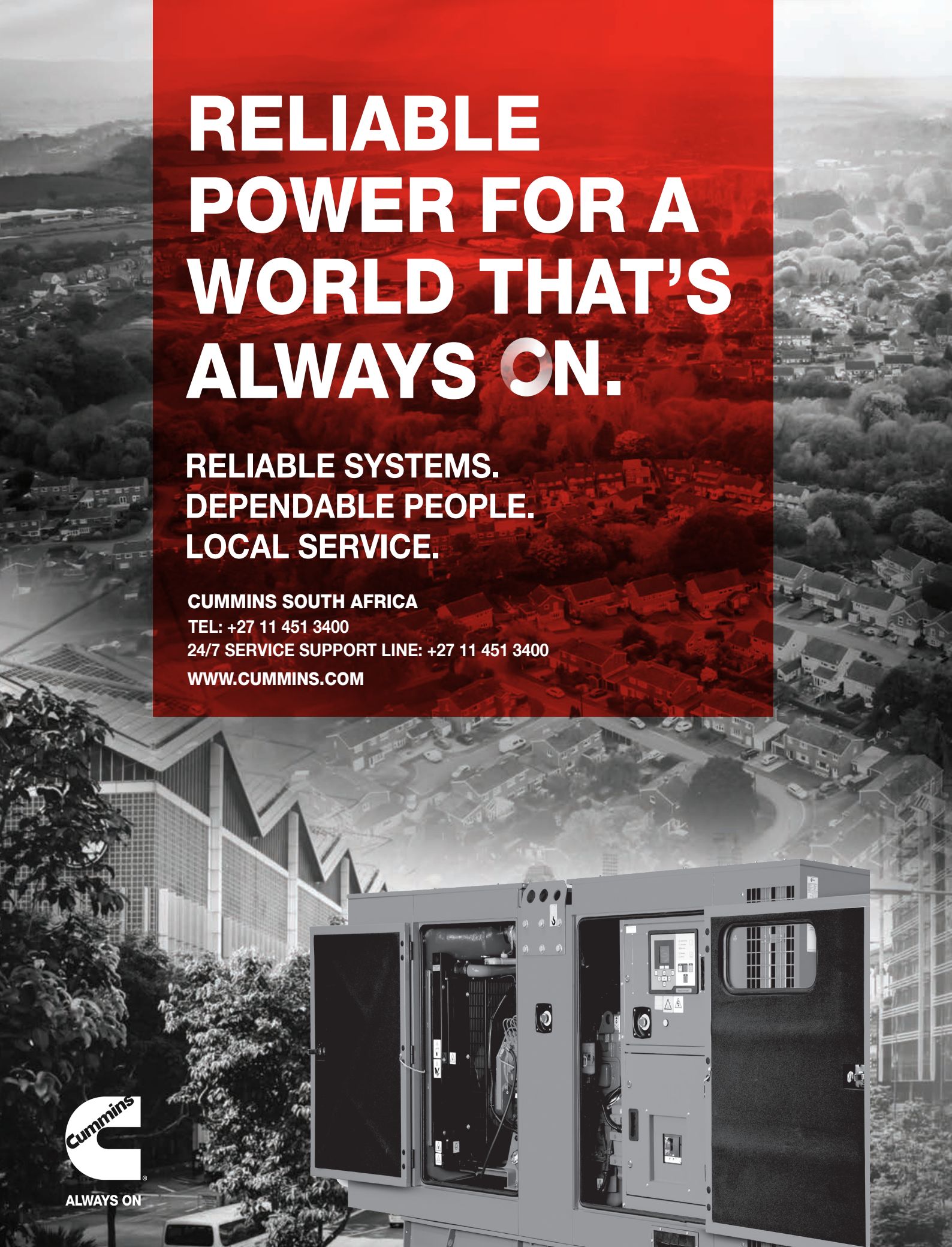
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