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WATER

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

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MANAGING EDITOR
Minx Avrabos I minx@saiee.org.za

TECHNICAL EDITORS
Jane-Anne Buisson-Street
Viv Crone
Thavenesen Govender

CONTRIBUTORS
L Petrik
L Green
AP Abegunde
M Zackon
CY Sanusi
J Barnes
F Catlow
D Basson
J Buisson-Street

EVENTS
Gerda Geyer I geyerg@saiee.org.za

CPD & COURSE ACCREDITATION
Sue Moseley I suem@saiee.org.za

MEMBERSHIP & TECHNOLOGY LEADERSHIP
Connie Makhalemele Maseko I connie@saiee.org.za

ADVERTISING
Avenue Advertising
T 011 463 7940 I F 086 518 9936 I E barbara@avenue.co.za

PUBLISHER
South African Institute of Electrical Engineers

SAIEE HEAD OFFICE
P.O. Box 751253 I Gardenview I 2047
T 011 487 3003 I F 011 487 3002
E reception@saiee.org.za I W www.saiee.org.za
Office Hours: 8am-4pm

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SAIEE 2018 OFFICE BEARERS

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2018 Q1 - 15 527

Johannesburg is in the grips of a cold front; we've had a few days of unexpected rain as we, in Johannesburg, are used to dry winter months.

Cape Town, however, has experienced fantastic rainfall - and we are all hoping that it will bring them out of the clutches of drought. Hopefully the Eastern Cape will get a break as well.

For that reason I decided to focus on Water this month – essential to our existence !

Our first feature article, on page 22, "Debunking desalination" is written by the World Wildlife Fund (WWF) and it explains how desalination works.

Page 26 sports a study on the effects of marine sewage outfalls. This paper discusses the implications for the governance of urban water as well as sewage treatment and desalination.

One of our SAIEE Members, Fred Catlow, wrote an article "Exploiting Technology for Commercial Use", which discusses the pros and cons of nuclear reactors. Find it on page 38.

Our dear Dudley Basson wrote another show-stopper - aptly named "Gravitational Velocity". Read it on page 52.

We are in the throes of organising the annual SAIEE Banquet - but this year, we are going all out! Not only is there a theme, "Masquerade Ball", there is plenty of other fun stuff to do.

Firstly, your MC is the enigmatic Loyiso Gola and our entertainment for the evening is none other than Evita Bezuidenhout. The venue will be the Midrand Conference Centre, with special price-reduced overnight stay packages organised for our guests. We will sport a VIP photo booth where you and your friends can totally hang out and have your prints done immediately - a keepsake of an evening never to be forgotten.

Get your company to book a table for 10 for only R6000 per table by emailing Gerda Geyer (email: geyerg@saiee.org.za). We also have sponsorship packages available - see page 5 for more information.

Herewith your July issue - enjoy the read!

Minx

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Our blue planet and the value of water...

DR HENDRI GELDENHUYS
2018 SAIEE PRESIDENT

It is not for no reason that we live on the blue planet; water and life as we know it, are inseparable.

Water brings joy to our lives, it brings back memories of ...

- walking on the beach early in the morning with the perfect mirror reflection of on the smooth wet beach sand that you get during daybreak, known to photographers as the "golden hour".
- beautiful flowers we have in our gardens thriving because it received tender love and.. water.

Water and our economy are inseparable, it is said that it takes 150 000 litres of water to make a car, 8 000 litres of water to make a shoe, 4 700 litres of water to produce a steak, 70 litres of water to create an apple and 120 litres of water to produce a glass of wine. (http://thevalueofwater.org/the-facts/waters-value)

The bottom line is that economic production requires a significant amount of water. Water is the lifeblood of our economy.

South Africa has limited water resources, and the Cape water crisis has brought this matter to the limelight. The Cape has a limited catchment area and limited water storage capability (I mean areas suitable for large dams). The Cape is far away from any other catchment areas from where it may have supplemented its water needs.

As much as the "drought" has been blamed for the water issue, the facts are just that the Cape reached the point where demand for water exceeded the available resource. The rest of South Africa is not too far from this point either.

Engineers generally but also, in particular, Electrical Engineers and Electrical Engineering are crucial to addressing our water supply going forward. Firstly we keep the "heart of the system pumping" it is electrical pumping stations. Equally knowing what the state of the system is, is the function of an information system that allows management of the supply of our economy's lifeblood.

Some of the challenges in this respect lie in limiting the loss of water from the system. Effective information systems and diagnostic capability are essential to address this issue. When it comes to energy efficiency, irrigation and water distribution have excellent opportunities for efficiency improvements.

Electrical Engineering colleagues, we are challenged to ensure the South African economy makes practical use of water and that it is delivered with efficient systems.

H Geldenhuys | SAIEE President 2018
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SAIEE WESTERN CAPE CENTRE: SANSA Visit

Back: T. Vuntu, M. Mahlangu, Prof M. Kosch, D. Rudman, R. Meyers, Degaussing Suite Manikin, H. Rudman, A. Barrier, T. Mtimkulu. Front: E. Fraser, Dr P. Cilliers, J. Sanzul, A. Spencer, M. Tshisaphungo, J. Mtimkulu, K. Rankunyane.

Members of the SAIEE Western Cape Centre participated in a visit to the upgraded facilities of the South African National Space Agency (SANSA) on the outskirts of the coastal town of Hermanus.

As the lights dimmed and the presentation title flashed on the screen: "The origin, prediction and impacts of Space Weather", this resulted in the perplexed question: "With space being a vacuum, how can it have weather?" But, this was the reason to intrigue attendees' attention and would be answered by Ms Mpho Tshisaphungo and Dr Pierre Cilliers.

Ms Tshisaphungo, Manager of the SANSA Space Weather Regional Warning Centre for Africa, addressed the origin and prediction of space weather. She showed the X-ray images of the sun streamed from NASA satellites and viewed on a video wall in the Space Weather Centre. These images, which are refreshed every 20 minutes, tell the history of recent eruptions on the Sun that emanating from active magnetic dipoles associated with sunspots and coronal holes.

The explosions of solar plasma flares are a result of the differential rotation of the Sun: 27-days per solar rotation at the Sun's equator and 35-days at its poles. This differential rotation flexes and bends the magnetic field lines inside the Sun, which results in ejections of high-speed particles into interplanetary space.

She also explained the importance of the SOHO (Solar Heliospheric Observatory) satellite which is located at a distance of 1 500 000 km from the Earth, in an orbit which keeps it between the Sun and the Earth. The SOHO satellite acts as "early warning" system of space weather impacts, since coronal mass ejections intercepted by the SOHO satellite, reach Earth about 1 hour later.

Solar eruptive events that occur on the surface of the Sun emits electromagnetic noise throughout the whole cosmos. On Earth, we can observe several phenomena associated with the arrival of the solar wind, which carries with it the magnetic field from the Sun, as Dr Cilliers explained. The most popular visible interaction occurs at high latitudes on Earth in the form of the Aurora lights. Other interactions resulting from a solar flare include increases in the ionisation levels to the point where high-frequency radio communication becomes impossible due to absorption of the electromagnetic energy in the lower layers of the ionosphere. Following a flare, the Sun also emits radio waves at enhanced levels for up to 24 hours. Geomagnetic storms, which can impact power systems, occur 2-3 days after the eruption and can last 1-4 days. There are many other noticeable solar events which cause interferences. For more information and to visit the facility, go to www.sansa.org.za.

ACTOM'S Metalplus and CSIR's National Laser Centre collaborate to boost laser-welding repair technology

Posing with the equipment are (from left) Jose Gomes, Metalplus' General Manager; Corney van Rooyen, CSIR NLC Welding Engineer; and Hardus Greyling, CSIR NLC Manager, Commercialisation & National Programmes.

The ACTOM group's mechanical repair business unit Metalplus and the CSIR's National Laser Centre (NLC) have agreed to collaborate in marketing and providing a laser-welding service to industry as an extension to the repair services Metalplus already provides.

The two-year collaboration agreement signed in January this year is aimed at further fostering use of fibre laser welding technology as developed by the CSIR NLC to perform specialised mechanical repairs on components that can't be repaired using conventional welding methods.

The well-proven fibre laser welding system performs weld overlays at low input energies and also has low dilution compared with other welding systems.

"It is used for repair of components that have suffered surface damage or wear and to improve the performance of components," explained Hardus Greyling, CSIR NLC Manager, Commercialisation & National Programmes.

"Due to its low heat input and low dilution it is also suitable for performing small-scale repairs and depositing fine layers of metal as weld overlays, which is beyond the scope of the traditional welding systems," he pointed out, adding that it is also able to weld a variety of alloys.

While occupying a niche market among industrial equipment repair applications, laser welding promises substantial savings to owners and users of high-value equipment.

"Typical examples of components best suited for rebuilding and repair by laser are rebuilding of worn tenons on Stage 3 power generation turbine blades, providing coil retaining ring landings on generator stator bodies and repairing worn labyrinth seals on compressor screws. This technology is especially well suited to repair of rotational equipment, where components may be at risk of suffering heat-distortion when conventional welding is applied," Greyling stated.

Laser-welding has about a tenth of the heat input of conventional welding, while its dilution is around 5%, compared with up to 50% in other welding processes.

Metalplus and the CSIR NLC have been collaborating for several years on an ad hoc basis in combining their respective capabilities in serving the mechanical repair market. In some instances operating equipment deployed by clients of Metalplus have required repairs to be done by CSIR NLC welding engineers and technicians using laser-welding technology, while Metalplus has assisted the CSIR NLC with machining services – both for pre-preparation of components in need of repair and for final finishing of components upon completion of laser-welding repair work.

"The collaboration agreement formalises these arrangements, while also providing for close cooperation between us in marketing our respective services in a unified way," said Jose Gomes, Metalplus' General Manager.

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Fixed-Mount IR Cameras for research analysis

The first fully-radiometric infrared cameras with software plug-ins to deliver continuous temperature monitoring for research, science and engineering applications

For precise research, science, and engineering applications, just seeing heat is not enough, it needs to be measured and analyzed as well. COMTEST is offering the new Fluke RSE300 and RSE600 Infrared Cameras, the first fully-radiometric, fixed-mount cameras with advanced features including software plug-ins to easily analyze thermal data.

The RSE300 and RSE600 cameras continuously stream up-to-60 frames of data per second, allowing for detailed monitoring of temperature patterns and variances. SmartView desktop software is included and allows users to remotely focus the camera, auto-capture images, adjust level and span, and analyze infrared videos frame-by-frame. The software also makes it easy to edit images, generate customized reports, and export images to multiple formats to share thermal data.

More RSE300 / RSE600 features are:

- Improved thermal analysis — thermal data from the infrared cameras can be pulled directly into MATLAB and LabVIEW, allowing users to statistically analyze and trend information.
- Identify heat buildup and dissipation — the cameras capture up to 640 x 480 resolution thermal/radiometric images and video to continuously identify heat buildup, as heat management becomes a priority in product development and testing.
- Test and troubleshoot — the cameras give users the flexibility to strategically mount the unit anywhere there is an electrical connection, remotely focus the camera, and transmit data and images to PC. Semi-fix the cameras to set up easily repeatable thermal experiments to troubleshoot and improve first pass quality.

These rugged cameras are IP65 rated so they can be mounted outside in harsh environments. There are optional 2x and 4x telephoto, wide, and macro lenses to customize for any measurement application.

An optional mounting bracket is also available for camera use at workstations.

For more information, visit www.comtest.co.za.

Renewable Energy Professional training in PE enjoys practical site visits

Training for certification as a Renewable Energy Professional (REP) at the Nelson Mandela University (NMU) always comes with a welcome bonus for candidates as they enjoy the vast variety of site visits to experience renewable and alternative energy solutions first hand. REP is an Association of Energy Engineers (AEE) program to distinguish professionals in the renewable energy industry through an internationally recognised certification program that requires continuous learning.

NMU and the Energy Training Foundation (EnTF) have over the last 3 years teamed up to present the REP program under the AEE license in Port Elizabeth (PE) with Dr Sean Poole from NMU. PE is a favourite training site for REP due to the added excursions for trainees at no additional costs. This year the group travelled in the electric Joule vehicles from NMU to visit the wind farms, whereafter they stopped over for a tour of the Rhino House in Crossways which operates completely off the grid. A visit to the algae plant, eYuilo mobility facility, solar research centre and the wind research, as well as the battery research facility added great value to experience renewable and alternative energy solutions in action. Refreshments and lunch for the excursion was sponsored by Rhino Energy.

DEHN AFRICA offers lightning and surge protection for renewable energy sources

Lightning strikes to renewable energy equipment on wind or solar farms, or rooftop solar panels, will cause damage at the strike point, as well as lightning 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.

Julienne Puttkammer, who is part of the Technical Team at DEHN AFRICA, says the company has concentrated most of its work in the renewables space to date on rooftop photovoltaic (PV) systems.

He says, *"Rooftop PV installations in South Africa are booming - we have been involved in a number of commercial rooftop PV projects, and find them being installed in places like shopping malls and other office buildings. These commercial entities are looking at PV installations from a long-term perspective, knowing that it makes economic sense over time to supplement their electricity requirements through self-generation. With regard to commercial rooftop PV installations, we find the highest lightning strike risk in Mpumalanga, followed by Gauteng and then Kwa-Zulu Natal. The owners of Cape Town commercial PV installations tend to be more concerned with surge protection than with lightning risks, while Gauteng owners are typically focused on both."*

Puttkammer explains that DEHN AFRICA has seen an increase in awareness over the past two years or so around the importance of surge and lightning strike protection for rooftop PV systems, as more people have learned how to implement them. He adds that DEHN AFRICA is also making its mark in the ground-mounted PV plants.

He clarifies, *"With respect to solar farms, we found that we were initially called in largely for retro-fitting and now, having been involved in a number of projects, we are increasingly being called in at the design stage of a new round of renewable energy projects, which is obviously more desirable from a technical standpoint.*

"In comparison, wind farm equipment is largely pre-made in Europe and then brought in to South Africa to assemble. It has lightning and surge protection already included or pre-specified, although we do some work on the earthing requirements for each local placement of the wind turbine."

WATTSUP

Positive outlook for manufacturing in KZN

According to jobs portal CareerJunction, in its index for the month of May 2018, the finance and manufacturing sectors have seen a recent upswing in hiring activity. This is a clear indication that the manufacturing sector could be entering a turnaround in fortune.

In the National Development Plan (NDP 30), Policy Context 2 in the Industrial Policy Action Plan for 2017/18 – 2019/20 addresses the importance of manufacturing in the country. According to the NDP presentation to the Portfolio Committee on Trade and Industry, *"The manufacturing sector has high economic multipliers because of its value-addition, linkages to the upstream production sectors of the economy (mining and agriculture) and the downstream sectors, including services; and because of its all-round contribution to strengthening integrated value chains."*

In his state of the province address (Sopa) in February, the KwaZulu-Natal Premier, Willies Mchunu said that provincial government remains committed to radical economic transformation to ensure inclusive, expanded and sustained economic output that creates more jobs. The provincial government's short-term focus, he added, would be on manufacturing, agriculture and tourism.

The KwaZulu-Natal Industrial Technology Exhibition (KITE), which is being held between 24 and 26 July 2019 at the Durban Exhibition Centre, is the ideal platform for industrial technology equipment and services providers to actively interact with manufacturing companies and government agencies.

"We are committed to providing industry with a forum to deliver added value to the manufacturing sector. Our exhibitors represent the cream of the crop in industrial technology development and innovation. These companies are able to provide the manufacturing sector with customised solutions that are characterised by their ability to increase productivity, decrease operating costs and ensure business sustainability," says Nick Sarnadas, portfolio director at Specialised Exhibitions Montgomery.

In addition to providing visitors with access to the knowledge base, experience and expertise inherent in the 150-plus exhibitors, KITE has a number of complementary visitor attractions that include the free-to-attend SAIMechE Seminar Theatre with approximately 18 seminar sessions on current trends and legislation.

"On the second day of the exhibition, we hope to once again host the MESA (Manufacturing Enterprise Solutions Association) special interest group as well as the Lifting Equipment Association of South Africa (LEEASA) conference. Both of these events proved very popular with the KITE 2017 visitors and provide yet another conduit for knowledge transfer," says Sarnadas.

Sales on the exhibitor stands are brisk and potential exhibitors are urged to book a stand at KITE 2019 or find out more information about the exhibition by visiting the website at www.kznindustrial.co.za.

LOOKING AROUND THE CORNER WITH LEUZE

Manufacturing plants, packaging facilities and warehouse operations often have areas where visibility is not what it should be, and not only can these prove hazardous to both vehicles and pedestrians moving in these areas but plant operators have limited visibility as well.

A solution, available from leading sensing solutions supplier Countapulse Controls, is the robust LCAM 408i IP camera which has been engineered for use in industrial environments. Correct positioning of the device will allow visibility into hard to see area with the 5 mexapixel colour camera delivering live stream at high image quality due to its gigabit Ethernet interface.

The housing of the robust Leuze LCAM 408i IP camera is rated at IP65/67 and features an easy to clean glass pane. It is easily integrated into machinery or system controls via M12 connections and requires only a 24 V voltage supply. Flexibility of installation is ensured through diverse mounting options including the use of dovetail, threaded holes as well as an extensive range of mounting accessories.
For more info, visit www.countapulse.co.za.

A new range of innovative DGA monitors enter the market

Launching in Southern Africa are the range of online transformer DGA monitors from MTE – Meter Test Equipment AG of Switzerland, distributed in Southern Africa by Martec.

Worldwide there are over 5 000 Hydrocal units installed. The MTE product range covers economical single gas and moisture monitors for smaller transformers right through to multi-gas (9 gasses plus moisture) for larger more critical transformers.

The newest product in the range is the Hydrocal 1004 genX, measuring 3 gases in oil (Hydrogen H_2, Carbon monoxide CO and Acetylene C_2H_2) plus moisture.

The Hydrocal has a unique design which combines a copolymer membrane for the extraction of the gas from the oil and (NIR) Near Infra-Red spectroscopy for the measurement of dissolved gasses in the transformer oil. Moisture content is directly measured in the oil through a capacitive sensor.

The Hydrocal range of On-Line DGA monitors are designed with few mechanical parts for maximum operability and are virtually maintenance free with no calibration required. It is also quickly and easily installed on the transformer with only one connection point. Another big plus, no carrier gases are required for this or any of the Hydrocal range therefore giving hassle free operation for up to 12 years.

The Hydrocal 1004 genX unit has a touchscreen display which is protected from the elements and has communication protocols (MODBUS, IEC 61850 and DNP 3.0) to facilitate wireless operation via dedicated modem or connected directly to SCADA systems or an electronic dashboard or a smartphone, notebook or tablet therefore providing remote access. For more information contact us and we will provide a demonstration.

Water at centre stage for Schneider Electric

Schneider Electric put water at centre stage during June, as it participated in the Water Institute of Southern Africa (WISA) biennial conference and exhibition.

"Scientists of the Joint Research Centre (JRC), the European Commission's Science and Knowledge service, released a technical report, analysing Southern African weather patterns and precipitation over the past 36 years," said Marc Ramsey, Vice President for the Industry Business Unit at Schneider Electric South Africa.

"The report found that there exists a strong probability of 50-70% monthly precipitation deficit every 5 years (more moisture lost through evaporation and transpiration than is gained through rainfall). In addition, they found an increasing number of moderates to extreme heat waves in Southern Africa over the last decade. These two factors combined – the repeated occurrence of high precipitation deficit and more frequent heat waves – exacerbate water shortages and could lead to crises that are more frequent in the future.

"Critical for Cape Town, this information is significant for all of South Africa and were in the minds of all participants at the WISA conference, with its timely theme of 'Breaking barriers, Connecting ideas'. At this conference, Schneider Electric exposed its major involvement in the water and wastewater sector and the technological advancements it offers to mitigate the growing crises around the world.

"Scarcity of water resources, growth in urban population, environmental regulations and process inefficiencies are all contributing to the crises. Only 0.3% of our global water resources can be used as clean drinking water and the energy to provide it accounts for 30-50% of total operating costs. It is estimated that the amount of energy wasted through traditional methods of water processing and delivery can be cut by up to 25%."

"Key to the reduction in water losses is that a comprehensive, integrated strategy be implemented by utility owners to leverage savings, implement infrastructure improvements, address non-revenue water and drive maximum benefits from an existing capital investment that may or may not be performing to its highest potential" Ramsey concluded.

ELPA delegates attend Annual Lightning Protection Industry conference in the US

A delegation from South Africa's Earthing and Lightning Protection Association (ELPA) recently attended the annual conference of the Lightning Protection Institute (LPI)/United Lightning Protection Association (ULPA) 2018 in Florida in the United States.

The attending team included ELPA National Director Richard Evert and former National Director Trevor Manas. The conference included two Annual General Meetings (AGMs) for the two associations and a Lightning Protection Installation (LPI) Inspection Programme (IP) update meeting.

Commenting on ELPA's decision to send a delegation over to the US at this particular time, Evert says, *"ELPA is a fledgling organisation focused on managing aspects of the lightning threat present within our country, and it has been formally in existence only since June 2017. The relationships among service providers as well as between service providers and end-users are critical to the success of the lightning protection industry in South Africa."*

"Since inception, ELPA's leadership has applied available local knowledge of association practices and business models. As the organisation grew, however, it also became apparent that acquiring intelligence around other potential business models and standard operating procedures could be helpful. ELPA's ability to meet the needs of its members will rely entirely on available knowledge, business acumen and the will to deliver what is needed."

With reference to the US Lightning Protection industry conference, Evert clarifies that there are three organisations making up the overall lightning protection coordinating body, and that the level of cooperation between them is impressive. He clarifies the structures as follows:

- The Lightning Protection Institute (LPI), founded in 1955, is the parent body addressing standards and business operations across the country and is a non-profit organisation. The LPI addresses the security of the industry. Its members are dedicated to ensuring that lightning protection systems installed are the best possible quality - in design, materials and installation - so that lives and property can be protected from lightning.
- The United Lightning Protection Association (ULPA) is the body that coordinates and supports the activities of the installers and technicians. ULPA places emphasis on the well-being of the people in the industry.
- The LPI-IP is the for-profit body responsible for ensuring that all lightning protection systems (LPS) installed by LPI/ULPA members are inspected and comply with the required specifications and regulations.

Evert adds, *"The LPI recognises that earthing and lightning protection is a specialised discipline where expertise is required for system design and installation. In the United States, an experienced lightning protection*

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ELPA visits ULPA

continues from page 14

specialist who is certified through the LPI will take into account the architecture of, and the contents in, a structure, without compromising industry safety standards for installation. Installation requirements according to the safety standards are specific and often complex, and the experienced and certified lightning protection specialist knows how to interpret the safety standards to meet all requirements with the completed installation."

ULPA was founded in 1936 with a long-standing history within the lightning protection industry. Lightning fatalities in America first started being recorded in the 1940s. Fatalities were similar to the figures we now have in South Africa in the order of several 100 per annum. With active intervention those statistics came down to an average of 51 people per year from 1984 to 2013. Last year, related deaths in the United States reached an all-time low, with a recorded history of 16 fatalities – this according to a year-end report published by the National Oceanic and Atmospheric Administration (NOAA). ULPA is credited with playing a role in helping to reduce these deaths.

Further to their efforts, the US lightning protection industry established the Lightning Safety Alliance (LSA) comprised of lightning protection manufacturers, distributors and installers. As a collaboration of groups including the National Lightning Safety Council, events are arranged to make the public aware of the dangers of lightning.

Evert states, *"The successes in the USA are not due to singular efforts or that one great solution, but a collaborative effort to take lightning seriously, driving education and awareness campaigns among the general public, and facilitating meaningful safety practices endorsed by those in the lightning protection industry. The USA experiences a significant annual lightning threat that is accumulatively comparable to that of South Africa. It was of real strategic importance for ELPA to attend this conference, as it provided the organisation with an opportunity to attend the board meetings of the associations responsible for managing the largest coordinated lightning protection association in the world. In addition to the two-day conference and the board meetings, we had the added bonus of being able to network with the other delegates, to better appreciate how the US lightning protection industry operates, as well as the standards that it applies."*

"Going forward, we envisage that the benefit to ELPA will include being able to grow our own knowledge further, and balancing South African conditions and circumstances with those of the USA, in order to identify 'horses for courses' circumstances that are common between our two countries."

Evert notes that in contrast with the situation in America, as outlined previously, South Africa has about 300 actual recorded deaths per annum, as verified by mortuaries – although this number is believed by many lightning experts to be significantly higher.

He says, *"Here at ELPA, we therefore look forward to emulating our American peers as we play our own role in the South African lightning protection industry and press on with our goal of becoming the recognised national professional body for the earthing and lightning protection industry. It is also vital that we acknowledge that lightning risk management did not start with ELPA in June 2017, and that the quality of work and best practices did not suddenly appear with its inception. SANS standards must be upheld at all times."*

Evert concludes, *"Through this public medium, we want to thank the US Lightning Protection industry for their open hearts and generosity and undertake that we will use the knowledge gained with the same passion and commitment they shared with us".* wn

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

Small Scale Embedded Generation Seminar
at SA Energy Storage, Smart Grid & SSEG 2018 Conference and Exhibition

Co-hosted by EE Publishers and SAIEE
Mon & Tue: 22 & 23 October 2018
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which has been expanded to include a dedicated concurrent **SSEG Seminar** on the regulations, standards, technology and business opportunities in **Small-Scale Embedded Generation** in Africa.

The concurrent **SSEG Seminar** will take place from 08h30 to 17h00 at Emperors Palace on Tuesday 23 October 2018, as an integral part of **SA Energy Storage 2018**.

www.energystorage.co.za

WAS Appointed as Local Distributor for Kurita

Middleburg based firm, Water Analytical Services (WAS), has entered into an agreement with Kurita, to become the global water technology solutions provider's official distributor for South Africa.

Kurita, based in Japan, is an international provider of water analysis and technology solutions and equipment. The Kurita Group provides comprehensive solutions through the integration of a variety of technologies, products, and services in three business areas: water treatment chemicals, water treatment facilities, and maintenance services.

Franco van der Merwe, WAS Managing Director commented on the appointment, saying: "Kurita offers high quality alternative with products that are as qualitative and competitive as the products that are currently available from other global suppliers. Going forward we can offer South African clients a highly advanced alternative that is both cost effective and field proven. I am very pleased to moving forward as an authorized Kurita distributor."

WAS is currently retailing Kurita's full product range – consisting of water treatment chemicals, chemical cleaning products and water treatment equipment – from June 2018. As one of the world's leading water treatment companies, Kurita offers exceptional technology suited for application in the automotive, steel, power, mining and petrochemical sectors. They have unique technologically advanced patents on various products, including paint detackification, polymers, amines, and biocides, among others.

"This technology will have the benefit of remarkable savings and value to clients with regards to wash-outs, boilers, RO's, effluent and cooling water management," van der Merwe comments. "Through this partnership WAS will be buying commodities and raw material directly from the source which will make a substantial difference to our clients' operational costs. As part of the CEA Group, WAS is also able to supply pumps, civils and a wide range of other services which help to ensure the highest standard of quality while remaining cost effective on bigger projects."

All of Kurita's equipment and products are focused on achieving smooth plant operation and reducing total cost of ownership. Their offering includes tailor-made water system monitoring equipment, ranging from simple dosing pumps up to specific dosing and monitoring systems for specific products and or special applications. Specific equipment is designed to measure and monitor the active substances and the key performance indicators (KPIs) which are important in your system.

The WAS team.

Kurita's water system monitoring equipment also allows the user to control product dosage and monitor of KPIs, optimise dosage of wastewater treatment products through online control, determine and monitor possible biofilm development in all water systems and benefit from online scaling monitoring for cooling water systems.

"We pride ourselves in building solid partnerships and are always looking for opportunities to improve our offering to ensure that our clients' operations are run safely and cost effectively. By partnering with Kurita, we are able to differentiate our client's experience across industries and add value to critical areas of production," van der Merwe concludes.

For more information, visit www.wateras.co.za

Diverse Mining Solutions Packaged

On display at Zest WEG Group's large outdoor stand at Electra Mining Africa this year will be not only its growing range of products but its integrated approach that offers customers significant added value in the execution of large projects.

One of the new products being launched at the event which is expected to draw the attention of visitors and customers is the WEG Motor Scan solution. This innovative device facilitates the monitoring of electric motor performance from a mobile phone and will help mines to avoid unplanned downtime.

According to Alastair Gerrard, integrated solutions executive at Zest WEG Group, the group's entrepreneurial approach to aligning with customer requirements has led to the cost effective packaging of its offerings.

"In today's mining sector, it is no longer enough to come to the market with a good product," says Gerrard. *"It is increasingly important to partner with customers in the design and delivery of integrated solutions that will enhance their bottom lines and achieve lower cost of ownership."*

The growth of Zest WEG Group's product portfolio – as well as the increased size of many aspects of its equipment range – will see the company consolidate its exhibition on one large outdoor stand near the show's main entrance.

"Moving with the trend of tailor-made solutions that leverage off our extensive portfolio, our integrated solutions approach will provide significant benefits to customers. It also strengthens our ability to supply and manage large projects," he says.

He emphasises the value of early engagement with customers, which facilitates an in-depth understanding of the specific demands of projects. This enables Zest WEG Group to identify where it can contribute added-value offerings, drawing on its diverse product range that includes electric motors, vibrator motors, variable speed drives, switchgear, motor control centres, mini-substations, generator sets, transformers, containerised or and mobile substations and E-houses.

Also, of interest will be WEG's recent acquisition of steam turbine manufacturing specialist TGM, which has a well-established reference base in the Brazilian market. Together with this, Zest WEG Group is growing its energy generation offering to include solutions in the renewable energy space.

Gerrard highlights the company's Level 2 B-BBEE status and its extensive local manufacturing capabilities with four standalone facilities, enhancing its procurement value to customers in the mining sector.

IINSERT BOX

WEG Motor Scan is a performance monitoring solution for electric motor installations. This innovative solution is designed to optimise access to information about the motor's performance and allows data to be extracted and sent to the cloud. The access to real-time information allows preventive actions to be taken, avoiding unscheduled downtime.

A fit-for-purpose custom built E-house for the Balama Graphite Project.

Information is collected by the App using either a smart phone or tablet device, in either Android or iOS versions, and is sent to the cloud via Bluetooth or gateway. The stored data can be analysed on the device screen in a dynamic way or in greater depth on the WEG IoT Platform.

WEG Motor Scan will allow the connection of all the sensors in the plant, enable naming and monitoring of as many electric motors as required, analyse data sent to the cloud and synchronise the data through the WEG IoT Platform. But, most importantly, this solution will allow end-users to find their motor from anywhere in the world. wn

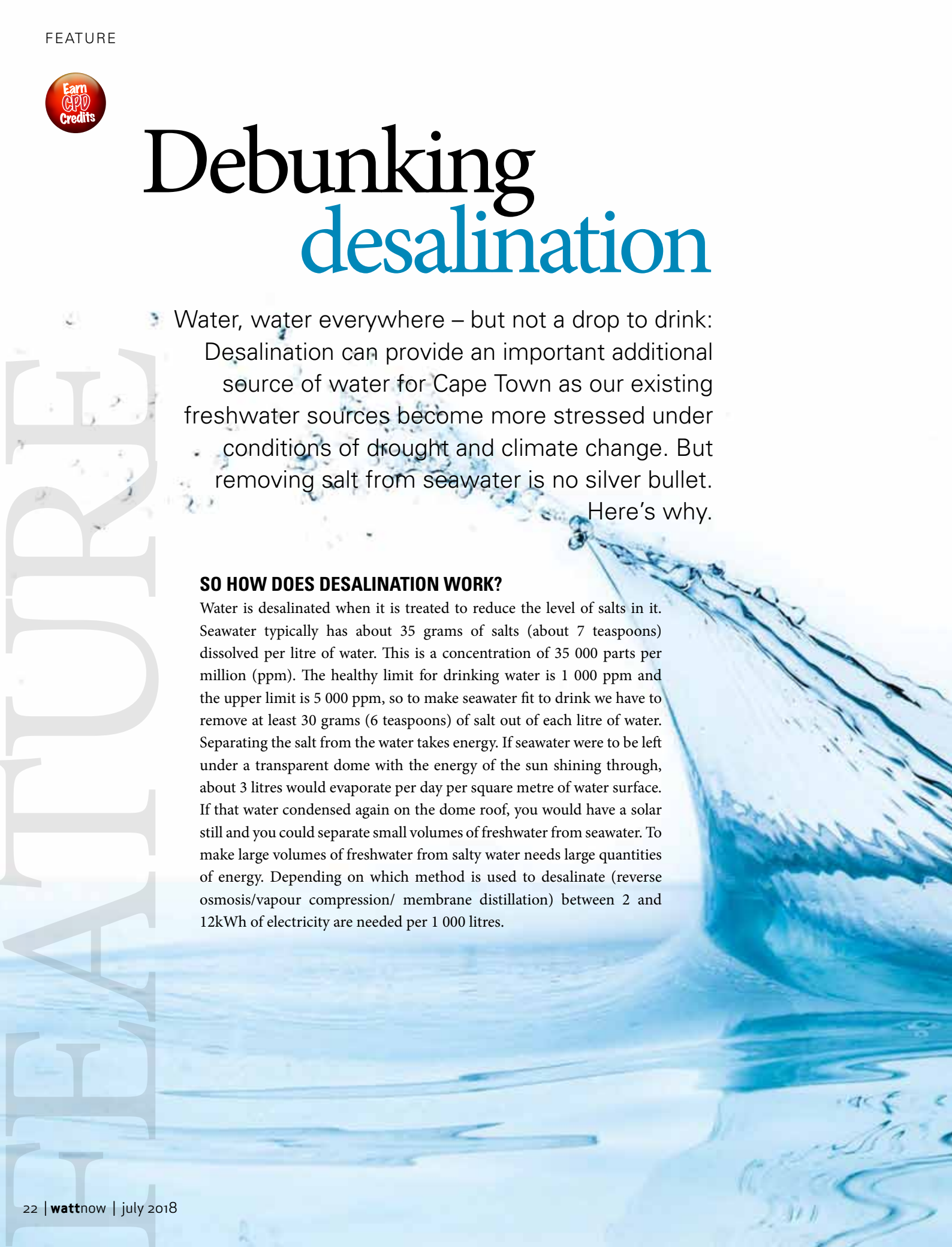
For more info, visit
www.zestweg.com

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

Earn CPD Credits

Debunking desalination

Water, water everywhere – but not a drop to drink: Desalination can provide an important additional source of water for Cape Town as our existing freshwater sources become more stressed under conditions of drought and climate change. But removing salt from seawater is no silver bullet. Here's why.



SO HOW DOES DESALINATION WORK?

Water is desalinated when it is treated to reduce the level of salts in it. Seawater typically has about 35 grams of salts (about 7 teaspoons) dissolved per litre of water. This is a concentration of 35 000 parts per million (ppm). The healthy limit for drinking water is 1 000 ppm and the upper limit is 5 000 ppm, so to make seawater fit to drink we have to remove at least 30 grams (6 teaspoons) of salt out of each litre of water. Separating the salt from the water takes energy. If seawater were to be left under a transparent dome with the energy of the sun shining through, about 3 litres would evaporate per day per square metre of water surface. If that water condensed again on the dome roof, you would have a solar still and you could separate small volumes of freshwater from seawater. To make large volumes of freshwater from salty water needs large quantities of energy. Depending on which method is used to desalinate (reverse osmosis/vapour compression/ membrane distillation) between 2 and 12kWh of electricity are needed per 1 000 litres.

WHERE IS DESALINATION MOST COMMON?

The International Desalination Association estimates that there are nearly 20 000 desalination plants worldwide producing water for over 300 million people.

The highest levels of use are seen in arid countries with few other options and relatively cheap and subsidised energy costs. Kuwait, for instance, gets all its drinking water from desalination.

WHAT ABOUT IN SOUTH AFRICA?

In South Africa desalination is used quite widely by mines to clean up polluted mine water and acid mine drainage.

Small to medium-scale desalination has also been used in coastal towns during times of drought. Six municipalities are currently using small-scale reverse osmosis plants to desalinate water for bulk water supply. Mossel Bay has a medium size desalination plant capable of producing 15 million litres of potable water per day but the plant is currently on standby as the dams in the area are full. Standby mode requires continuous maintenance to keep the plant functional which costs the municipality money whilst not producing any water.

The Knysna Municipality has a desalination plant capable of producing 2 million litres per day which is currently shut down for maintenance and repairs. During normal operation, the plant is used at the discretion of the municipality. Currently there is sufficient water in Knysna so use of the plant is minimised due to the high operational costs.

Plettenberg (Bitou Municipality) has an operational desalination plant producing 2 million litres per day.

There are two desalination plants in the Ndlambe municipality, namely the Bushman's River Mouth and Cannon Rocks plants, that produce 1.8 and 0.75 million litres per day respectively. Both plants are currently producing at full capacity.

Debunking Desalination

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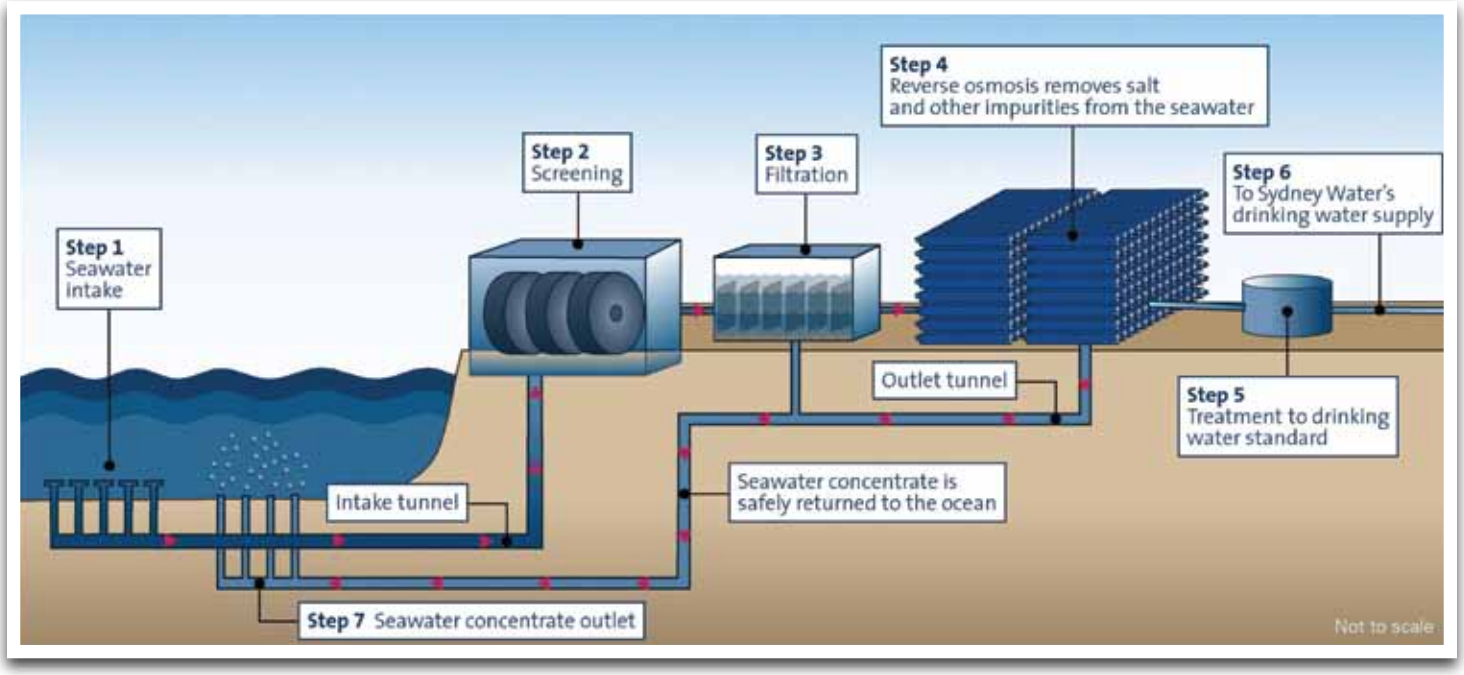


The Cederberg Municipality has a plant in Lamberts Bay with a capacity of 1.7 million litres per day (upgradable to 5 million litres per day); however, this plant is not operational yet as it is still newly developed.

Richard's Bay has a desalination plant that was installed during the 2016/17 drought to provide the town with 10 million litres per day. It has been operating at an average rate of 6 million litres per day. The plant has had several problems, particularly cable theft, which has interrupted supply, and excessive pressure, which resulted in pipe bursts in the areas receiving water.

WHAT DESALINATION IS IN THE PIPELINE FOR CAPE TOWN?

Four of the seven augmentation projects that will bring new water online for Cape Town are desalination plants. They are based at the Waterfront, Cape Town harbour, Monwabisi and Strandfontein (the latter two on the False Bay coast). These are relatively small-scale operations. The City has been criticised for initially trying to bring on smaller and quicker plants to provide water during a Day Zero scenario as these are more expensive. At one stage we were going to bring in desalination barges.

Barges have only worked successfully in more sheltered sea areas in the Red Sea and the Gulf. There is very little international capacity in this market at the moment, and this is currently not a viable option for Cape Town. Barges are also generally more expensive than land-based desalination.

SO WHY AREN'T WE DOING MORE DESALINATION IN CAPE TOWN?

For arid and drought-stricken coastal cities, desalination can be an important source of water which is completely independent of local rainfall. However, desalination remains the resource of last resort for most cities because it is the most expensive. Desalination takes longer to bring online than drilling the shallower boreholes in Atlantis and the Cape Flats. Desalination would also be more cost-effective at larger scales – between 150 to 200 million litres per day would be the best economy of scale for Cape Town.

WHAT OTHER CONSTRAINTS ARE THERE?

The availability of electricity is also a potential issue. Concerns have been raised in the United States that electricity supplies in local grids are not able to accommodate new desalination plants built in response to the Californian drought. South Africa is not long out of an electricity crisis. A further energy crisis at the same time as a water shortage would place this source at risk. Some plants overseas are starting to operate with solar energy, and this could be an option for Cape Town in the long-term.

At the moment most of our energy is generated using coal-fired power stations and this means our energy generation puts a lot of greenhouse gases (GHGs) into the

atmosphere which is a cause of climate change – which in turn would fuel future droughts.

WHAT IS CLIMATE-NEUTRAL DESALINATION?

Climate-neutral desalination relies solely on renewable energy which doesn't produce GHGs and contribute to climate change. There are some examples of solar-powered desalination in California, however these costs are even higher than conventional desalination at this point.

ARE THERE ANY OTHER ENVIRONMENTAL CONCERNS?

Desalination plants need to take in twice as much seawater as they produce freshwater. Often the intake points take in small organisms (fish larvae, plankton, etc) which can reduce local fish populations. A quantity of very concentrated brine is then produced, that generally will be disposed of back to the sea.

As well as being very salty (which is toxic, even in a marine environment) this brine contains biocides and antifouling chemicals used in the desalination process which can also harm marine life.

HOW EXPENSIVE IS DESALINATION COMPARED TO OTHER WATER SOURCES?

Globally desalination is between two to four times as expensive as most other sources depending on the relative cost of capital equipment (how much has to be imported etc), the cost of energy and the cost of labour to implement other water savings. By way of comparison the costs for Cape Town would be:

- Raw surface water between R1 and R4 per kilolitre;
- Alien clearing to release more water from our catchments - from R6 to R15 per kilolitre;
- New groundwater - around R15 per kilolitre;
- Reclaiming and re-using treated waste water - between R10 and R20 per kilolitre;
- Large-scale, permanent desalination - between R10 and R22 per kilolitre; and
- Smaller, short-term desalination - R34 to R44 per kilolitre.

WHAT ARE THE LONG-TERM LESSONS HERE?

Cape Town may need one larger scale desalination plant in the long-term. This would add a drought-proofed water source into our bulk supply.

However, we have been warned about over-investing in a source that other (wealthier countries) have had to mothball because of excessive energy costs.

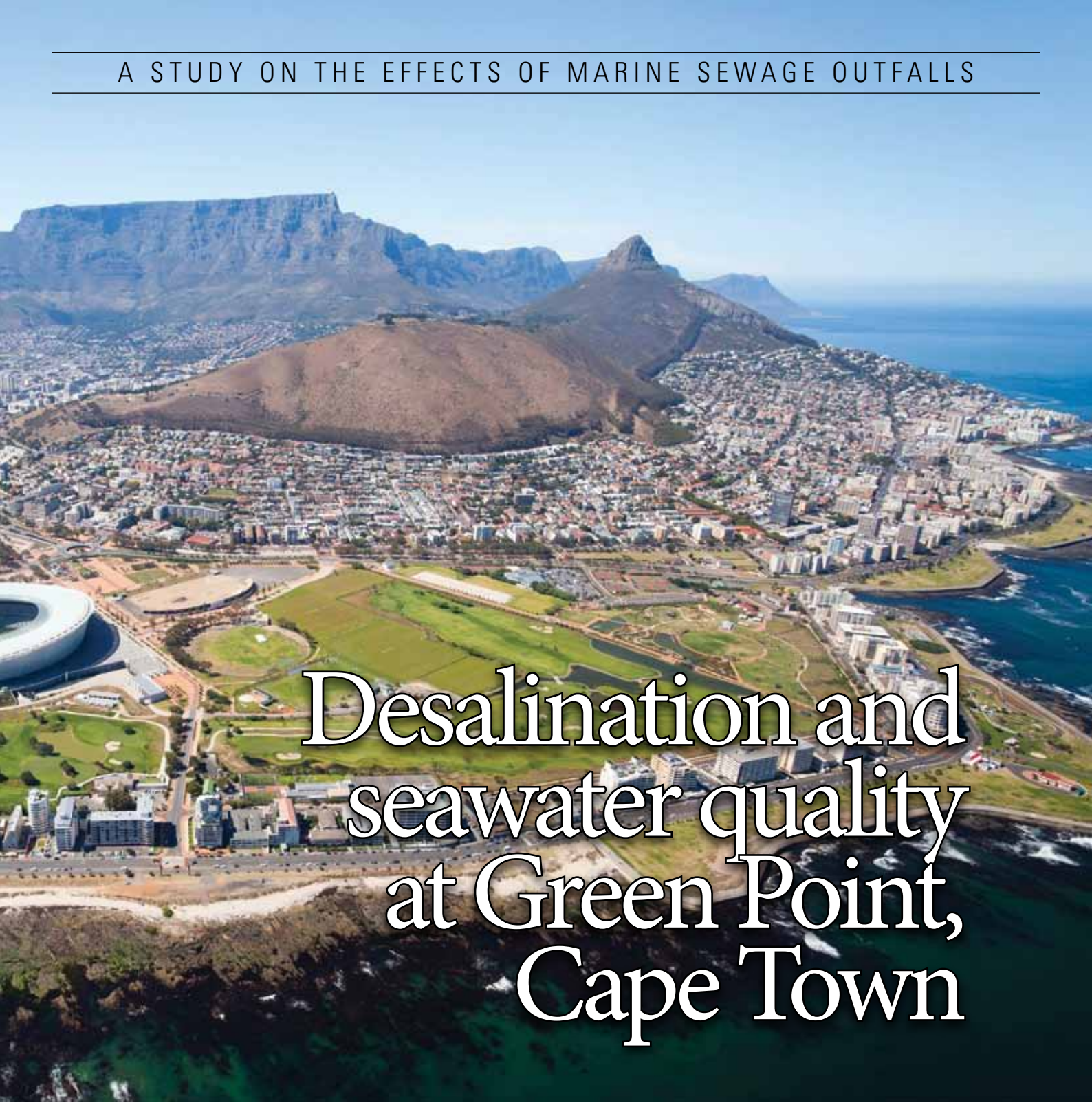
In Australia, the severe drought from the mid-1990s until 2012 prompted the construction of six large-scale seawater desalination plants at a cost of $10 billion Australian Dollars. The plants took years to build. Meanwhile, the National Water Initiative implemented water policy reforms and improved efficiency measures that led to cheaper water supply alternatives.By the time the plants were operational, the drought was over and the more cost-effective alternatives made desalinated water prohibitively expensive. Most of these facilities have stood idle, and operated at a significantly reduced capacity. WN

BY | L. PETRIK | L. GREEN | A. P. ABEGUNDE
M. ZACKON | C. Y. SANUSI | J. BARNES

This paper presents our collection methods, laboratory protocols and findings in respect of sewage pollution affecting seawater and marine organisms in Table Bay, Cape Town, South Africa, then moves to consider their implications for the governance of urban water as well as sewage treatment and desalination.

A series of seawater samples, collected from approximately 500 m to 1500 m offshore, in rock pools at low tide near Granger Bay, and at a depth under beach sand of 300–400 mm, were investigated for the presence of bacteriological load indicator organisms including Escherichia coli and Enterococcus bacteria.

A second series of samples, comprised of limpets (Patella vulgata), mussels (Mytilus galloprovincialis), sea urchins (Tripneustes ventricosus), starfish (Fromia monilis), sea snails (Tegula funebralis) and seaweed (Ulva lactuca), was collected from rock pools at low tide near Granger Bay. Also sediment from wet beach sand (and from where the



Desalination and seawater quality at Green Point, Cape Town

organisms were found) close to the site of a proposed desalination plant and a number of recreational beaches. In several areas it was found that high levels of microbial pollution were noted, and 15 pharmaceutical and common household chemicals were identified and quantified in the background seawater and bioaccumulated in marine organisms. These indicator microbes and chemicals point to the probable presence of pathogens, and literally thousands of chemicals of emerging concern in the seawater. Their bioaccumulation potential is demonstrated.

In respect of proposed desalination, the findings indicate that desalinated seawater must be subjected to treatment protocols capable of removing both bacterial loads and organic chemical compounds. The terms of reference for desalination plants must specify adequate testing and monitoring of chemical compounds as well as microorganisms in the intake and

Desalination in Cape Town

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recovered water. Drinking water supplied by the proposed seawater desalination plants should be carefully tested for its toxicity.

In respect of water management, our findings suggest the need for the City of Cape Town to move to an integrated water and sewage management plan that treats urban water, including seawater, as a circulating system that is integral to the health of the City, and which excludes marine outfalls.

BACKGROUND TO THE STUDY

The ongoing drought in the Western Cape has led to the proposal to produce drinking water via seawater desalination plants for the City of Cape Town. The terms of reference provided in the tender documents make the assumption that the tens of millions of litres a day of untreated sewage effluent currently discharged into the ocean, via the marine outfalls located around the Peninsula, are to be dispersed out to sea, and that intake seawater to the desalination plants will contain only inorganic salts, and not organic chemical pollutants or microorganisms.

However, kayakers, long-distance swimmers, and citizen groups like the Camps Bay Ratepayers, etc. have claimed that untreated effluent from the marine outfalls washes back to shore in specific conditions. Where positive independent E. coli counts have been demonstrated, such as those collected by public health researcher Edda Weimann, the City has argued that the E. coli results are a result of stormwater run-off.

Resolving the matter requires evidence of factors that can only have been sourced from human sewage, such as specific bacteriology and pharmacological compounds. These can only have entered seawater via faecal contamination from the marine outfalls and not from surface run-off. If those compounds are present, the findings have relevance to the City's desalination plants, beach management and sewage management system.

Persistent organic pollutants include pharmaceutical and personal healthcare products such as over-the-counter and prescription drugs (antibiotics, analgesics, blood lipid regulators, natural and synthetic hormones, β-blockers, antidiabetics, antihypertensives, etc.), household products such as soaps, detergents, disinfectants, perfumes, dental care products, skin and hair products, and surfactants, as well as these compounds' degradation products. There is growing evidence that certain emerging contaminants could affect human and environmental health. For example, the veterinary use of diclofenac, which is also a human pharmaceutical (used as an anti-inflammatory treatment), was found to be responsible for the massive decline in populations of vulture species in certain areas of Asia; ethinylestradiol, one of the active ingredients in the contraceptive pill, has been associated with endocrine disruption and feminisation in fish. There is concern that long-term exposure to antibiotic pharmaceuticals and disinfectant products may be contributing to the selection of resistant bacteria with significant impacts upon human health. In South Africa, Ncube et al. suggested a protocol for the selection and prioritisation of contaminants in drinking water. Patterton surveyed seven cities in South Africa and showed the presence of 32 compounds in drinking water, predominantly pharmaceuticals and pesticides, including carbamazepine (anticonvulsant), phenytoin (antiepileptic) and diclofenac. Osunmakinde et al. compiled a priority list including the antiretroviral lamivudine, based on data collected from the health sector in South Africa. These compounds could cause far more harm than the sewage itself, such as feminisation or sterility of fish populations, cancer, growth deformities, foetal abnormalities and hormonal disturbances. These compounds may bioaccumulate in marine organisms, and thus move up the food chain to humans who eat seafood, ultimately causing the same effects. Also in South Africa, Swartz et al. identified carbamazepine, sulfamethoxazole (antibiotic), triclosan (biocide), bisphenol A (plasticiser) and caffeine (stimulant) amongst others as priority pollutants for water quality assessment in water reuse.

These authors stated:
The priority list cannot be seen as an exhaustive list as each reclaimed potable water reuse project should interrogate the relevance according to the speci c area to consider whether extra chemicals might need to be added to the priority list.

These authors also reported that many of the compounds tested for, escaped through the conventional wastewater treatment plants in trace quantities into the environment. For instance, α-ethinylestradiol, which has a recommended reference dose of 0.0015 µg/L, was present in some effluents at levels of 2–6 µg/L. This study presents the laboratory findings from seawater, sediments as well as samples of marine organisms collected near the marine sewage outfalls in Green Point, close to the site of the proposed Granger Bay desalination plant.

WATER SAMPLES: COLLECTION METHODS AND LABORATORY PROTOCOLS

Seawater samples for microbiological and chemical testing were collected at 22 different points (Figure 1) near Granger Bay in the months of June, July and August 2017, together with kayakers on days on when winds and swell conditions allowed for kayak trips. In addition, seven samples were taken of water from beach sands of the intertidal swash zone at depths of approximately 300 mm. All water samples for microbiological testing were collected in bottles provided by the South African Bureau of Standards (SABS) and samples were delivered to the SABS laboratories in Rosebank, Cape Town. Tests were requested for E. coli as the indicator organism of choice for checking sewage contamination in fresh water (while Enterococcus is more stable in seawater).

At the SABS laboratories, samples were tested in terms of the SANS 5221 protocol for E. coli and SANS 7899 for Enterococcus. Figure 1 shows the location of sampling points in the ocean and on the shoreline and flags the hot spots of contamination above the Blue Flag limits of 250 colony-forming units per 100 millilitres (CFU/100 mL).

MICROBIAL FINDINGS

The results of microbial tests for seawater and beach water samples are consistent with kayakers' claims that on occasion the water is a health risk. While the majority of markers were clear, there was significant variability. One sample (taken 1.7 km from shore) contained an E. coli count of 12 650 CFU/100 mL. This sample was collected on the edge of what kayakers identified as the sewage plume that had led to several complaints. Although the plume

Figure 1: Location of sampling and microbial load of seawater and beach water (Granger Bay, Cape Town).

was visibly more dense further at, the kayakers were not willing to risk paddling into it to collect additional water samples. On the same day, a sample taken 1 km from the shore contained an E. coli count of 4700 CFU/100 mL.

Water collected from sand evidenced similar variability. One sample contained an Enterococcus count of 1460 CFU/100 mL and that on another day had a count of 7200 CFU/100 mL. The majority of microbial results were within specification, as shown on the map.

DISCUSSION

In 2014, Edda Weimann, an endocrinologist, published a paper challenging the City's use of the Blue Flag ensign to promote its beaches. Her samples, taken six times at Clifton Beach over a 4-week period in early 2013, showed that only on one day was the E. coli level within the Blue Flag acceptable range of below 250 CFU/100 mL and Enterococcus below 100 CFU/100 mL. On two separate days she found the values for E. coli had been in the tens of thousands, and on a further two days the values ranged in the hundreds of thousands and closer to one million. Nonetheless, on every day that she had sampled Clifton's waters, the Blue Flag had been hoisted. Weimann's findings contradict Blue Flag's criteria pertaining to water quality.

Both Weimann's findings and ours suggest that predictive modelling will be more effective in managing potentially hazardous beach sewage levels than the form of water quality monitoring currently used in the City via the Blue Flag protocols, which are used to assert the health of the seawater on the basis of one or two samples taken per month.

Predictive modelling is consistent with South Africa's policy for the disposal of land-derived wastewater in the sea, published in 2006.

Desalination in Cape Town

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Because seawater is constantly in a state of movement we also investigated the presence in marine organisms of compounds that could only come from long-term exposure to sewage-contaminated seawater. A variety of species was collected from rock pools at low tide near Granger Bay (Figure 1).

BIOACCUMULATION OF PERSISTENT ORGANIC POLLUTANTS IN MARINE ORGANISMS

The selection of compounds for this study was based on their known persistence in the environment as well the availability of testing protocols and standards. The compounds tested for included perfluorinated compounds and a variety of pharmaceuticals, a cleaning agent, caffeine and bisphenol A.

Caffeine (Ca) was chosen as a broad indicator of faecal contamination. Caffeine passes from the human digestive system via faeces into the environment in unmodified form. Perfluorinated compounds are a large family of synthetic chemicals, broadly used in industrial and consumer products. They are used as industrial surfactants and surface protectors for food containers, paper, leather, carpet, fabric coating and firefighting foams because of their water and oil repelling ability.

Among other things, Perfluorinated compounds selected here include perfluorooctanoic acid (PFOA), perfluoroheptanoic acid (PFHpA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA) and perfluoroundecanoic acid (PFUnDA). Pharmaceuticals tested for were acetaminophen (ACT), diclofenac (DSS), lamivudine (LA), phenytoin (PHE), carbamazepine (CAR) and sulfamethoxazole (SUL). The household product tested for was triclosan. Triclosan (TS) is an antibacterial and antifungal agent commonly found in household and personal cleaning products including some toothpastes. The industrial chemical tested for was bisphenol A (BPA), which is an organic synthetic compound that mimics oestrogen, that is used in plastics, the lining of some food and beverage cans and thermal paper used in point-of-payment slips.

SAMPLE COLLECTION AND HANDLING

Limpet (Patella vulgata), mussel (Mytilus galloprovincialis), sea urchin (Tripneustes ventricosus), starfish (Fromia monilis), sea snail (Tegula funebralis) and seaweed (Ulva lactuca) samples were collected from rock pools along the shoreline near Granger Bay in 2017. In 2015, samples were collected at a depth of ~30 m in the ocean close to the marine outfall diffusers. Samples were wrapped in foil and stored on ice for transportation to the laboratory. (All marine organism samples were delivered to the laboratory within 1 h of collection, and stored at -20 °C at the laboratory.) The samples were analysed according to the following protocols:-

ANALYTICAL PROTOCOLS

All sample bottles, extraction and volumetric flasks used were washed in methanol, rinsed with tap water and deionised water, then air dried.

REAGENTS

Methanol, acetonitrile and acetone were HPLC grade. The standards, purchased from Sigma Aldrich (Johannesburg, South Africa), were:

- perfluorooctanoic acid (PFOA 96%);
- perfluoroheptanoic acid (PFHpA 99%);
- perfluorononanoic acid (PFNA 97%);
- perfluorodecanoic acid (PFDA 98%);
- perfluoroundecanoic acid (PFUnDA 95%);
- bisphenol A (≥99%);
- acetaminophen (≥99%);
- caffeine, ibuprofen sodium salt (≥98%);
- diclofenac sodium salt;
- lamivudine (≥98%);
- triclosan (≥97%);
- phenytoin, sulfamethoxazole (≥97%);
- sulfisoxazole (≥99%) and
- acetaminophen-d4 (≥97%).

Ultrapure water was purified using a Milli-Q system (Millipore, Bedford, MA, USA).

Primary stock solutions of individual analytes were prepared in methanol at a concentration of 1000 µg/mL and appropriately diluted in methanol.

SAMPLE PREPARATION: EXTRACTION AND CLEAN-UP

In this study, Oasis HLB was selected over Strata X cartridge for sample extraction.

WATER SAMPLES

Seawater samples of 500 mL were extracted based on the method used by Valdés et al., with some modifications. The extract was concentrated to 2 mL under a gentle nitrogen stream and then transferred to amber vials and centrifuged for 25 min prior to analysis.

TISSUE SAMPLES

Tissue from marine organisms was freeze dried and ground into a fine powder. Approximately 10 g was weighed and placed into an extraction thimble.

Surrogates (sulfisoxazole, acetaminophen-d4) were added to each sample. The mixture was extracted with 100 mL methanol/acetone 3:1 (v/v). The extract was concentrated to 10 mL using a rotary evaporator at reduced pressure, and the sample pH was adjusted to 6 by adding 1 M NaOH or HCl so as to allow the precipitation of lipids. The extract was centrifuged at 3000 rpm for 20 min. The supernatant was transferred to glass bottles and Millipore water was added to make up to a volume of 100 mL.

These aqueous extracts were further extracted and cleaned using the procedure of Valdés et al. for seawater samples. The final eluate was concentrated under nitrogen and then reconstituted to 2 mL with methanol. Recovery standards were added to each sample prior to analysis.

CHROMATOGRAPHIC CONDITIONS

The chromatographic separations were performed with the Acquity UPLCTM (Waters, Milford, MA, USA).

Simultaneous determination of all the compounds of interest was achieved using an Acquity UPLC BEH C18 1.7-µm column (2.1 mm × 1000 mm) with an Acquity BEH C18 1.7-µm VanGuard™ precolumn (2.1 mm × 5 mm), supplied by Waters. The column temperature was set to 50 °C. The mobile phase consisted of a mixture of 0.02 M formic acid (solvent A) in water and acetonitrile (solvent B). Linear gradient elution of 0.35 mL/min was used starting with a mixture of 80% solvent A and 20% solvent B for 9 min. At 10 min, the acetonitrile percentage was increased linearly from 90% to 100% and was later maintained at 80% of solvent A and 20% of solvent B. A volume of 5 µL of each sample was injected into the LC/MS system. Standards and the test samples were subjected to a 12-min chromatographic run.

MASS SPECTROMETRY

The UPLC was coupled to a triple quadrupole mass spectrometer (Xevo TQ-MS), with an electrospray ionisation source. During optimisation, a multiple reaction monitoring scan mode was generated for all analytes. In addition, for maximum sensitivity, other conditions such as source temperature, capillary voltage, cone voltage, cone gas flows and desolution temperatures were standardised. This standardisation was achieved by direct injection of stock solutions with a concentration of 10 µg/mL. A capillary voltage of 3.5 kV, desolvation gas (N2) flow of 800 L/h, source temperature of 140 °C and desolvation temperature of 400 °C were finally used. The analytical operation control and data processing were performed with Masslynx software.

METHOD MODIFICATION, VALIDATION, QUALITY CONTROL AND CALIBRATION

The volume of each water sample used for the extraction technique was increased from 250 mL to 500 mL. To ascertain the concentration and consistency in the extraction technique for all the analytes, each extraction round was triplicated. The analytical method was validated using EU Commission Decision 2002/657/EC as a guideline. To show the applicability of the analytical method, a validation study was carried out. The validation procedure included the assessment of method linearity, specificity/selectivity, precision, recovery and calculation of the limits of detection and quantification. Six-point calibration curves were constructed (four replicates). The multi-matrix capacity of the analytical technique was checked with an identical validation study using ultrapure water and seawater. To monitor for potential contamination, blank samples of ultrapure water were extracted and analysed along with the seawater samples and laboratory spikes. Methanol blanks were also run between samples in order to monitor for instrumental contamination and carry-over. None of the compounds of interest was detected in the ultrapure water and reagents used. Chromatographic peak area, signal noise and height were used to define and quantify the analytes of interest. Calibration standards were analysed prior to each analysis batch. The final analyte concentration was calculated as follows:

$$\text{Final analyte concentration} = \frac{\text{initial concentration x sample volume injected}}{\text{sample volume extracted}}$$

FINDINGS: ORGANIC POLLUTANTS IN MARINE ORGANISMS AND SEAWATER

All 15 indicator chemical compounds were present in the seawater samples in trace concentrations (Figures 2 to 4) and considerably higher levels were present in limpets (Patella vulgata), mussels (Mytilus galloprovincialis), sea urchins (Tripneustes ventricosus), starfish (Fromia monilis), sea snails (Tegula funebralis), seaweed (Ulva lactuca) and sediment samples (Figures 5 to 7). The high levels of all the chemical compounds in marine organisms are evidence of bioaccumulation over time as the organisms have no way of escaping the pervasive presence of these chemicals in the seawater. The significant increase in their levels in 2017 against our findings of 2015 (Figure 8) is noteworthy. None of these compounds would

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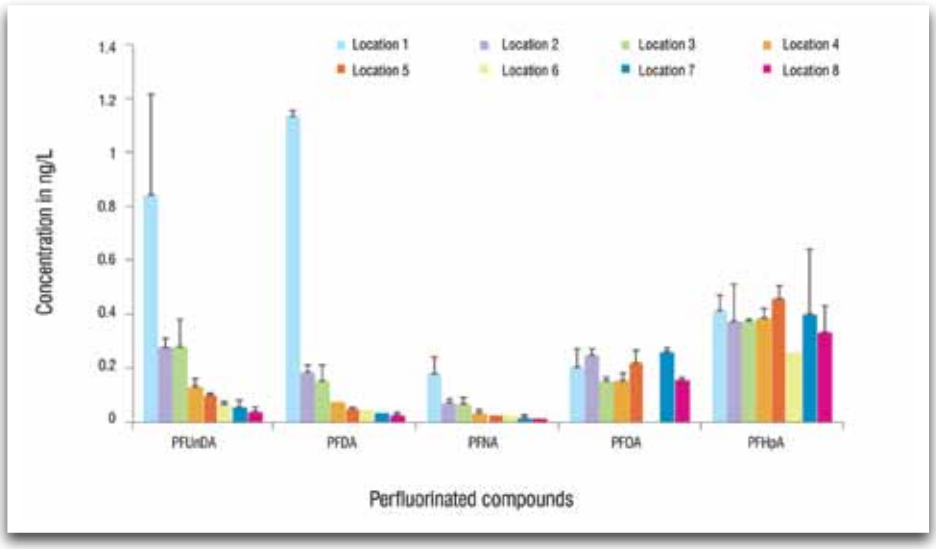
normally be found in seawater and should definitely not be present in these marine organisms. With the exception of caffeine, all are manufactured substances. The finding that all 15 tested compounds were present in every organism and in the background sediments and seaweed tested, is a clear indication of faecal pollution of the shoreline, and that additional chemical substances are likely present in the seawater and thus in the marine organisms.

DISCUSSION

Pharmacological compounds such as the analgesic and anti-inflammatory drugs acetaminophen (also known as paracetamol) and diclofenac, the anti-seizure medication phenytoin, the antibiotic sulfame-thoxazole and the antiretroviral lamivudine are made to be stable and effective at low doses. They are polar, lipophilic, soluble and nonvolatile compounds.[20] For these reasons, many pharmaceutical compounds or secondary metabolites do not decompose, but survive in the environment to become persistent organic pollutants. Unknown quantities of partially metabolised drugs which may be toxic are also released in faeces and urine.

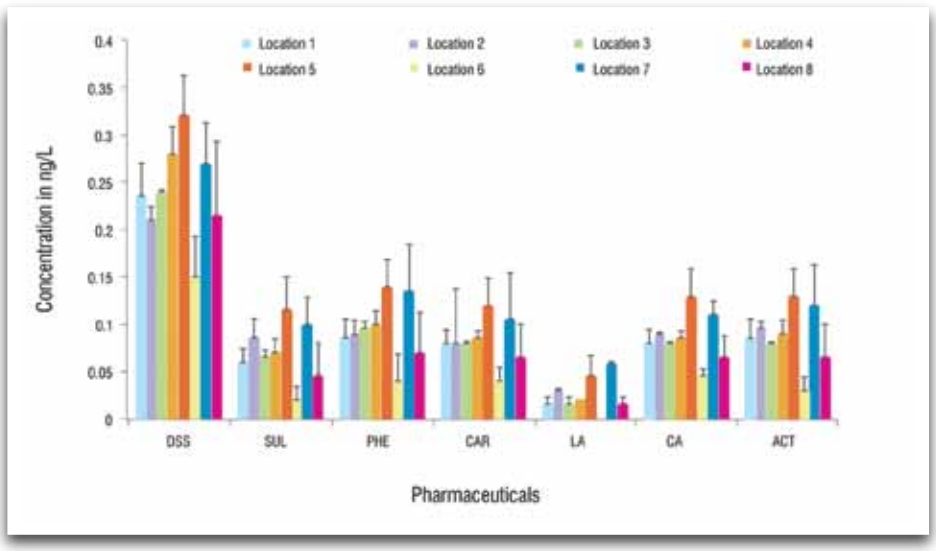
Their molecular sizes in the nanometre(10^{-9}) and Angstrom range (10^{-10}) make it impossible for marine organisms to exclude them. It has been widely reported that these compounds are continuously released into the environment, and bioaccumulate in wild-caught fish populations at concentrations of nanograms per gram. Huerta et al. showed that diclofenac and carbamazepine were the most highly bioaccumulated at 18.8 ng/g in fish liver.

Current regulations do not specify that they should be monitored in our water supplies or in sewage effluents (South African National



PFUnDA, perfluoroundecanoic acid; PFDA, perfluorodecanoic acid; PFNA, perfluorononanoic acid; PFOA, perfluorooctanoic acid; PFHpA, perfluoroheptanoic acid

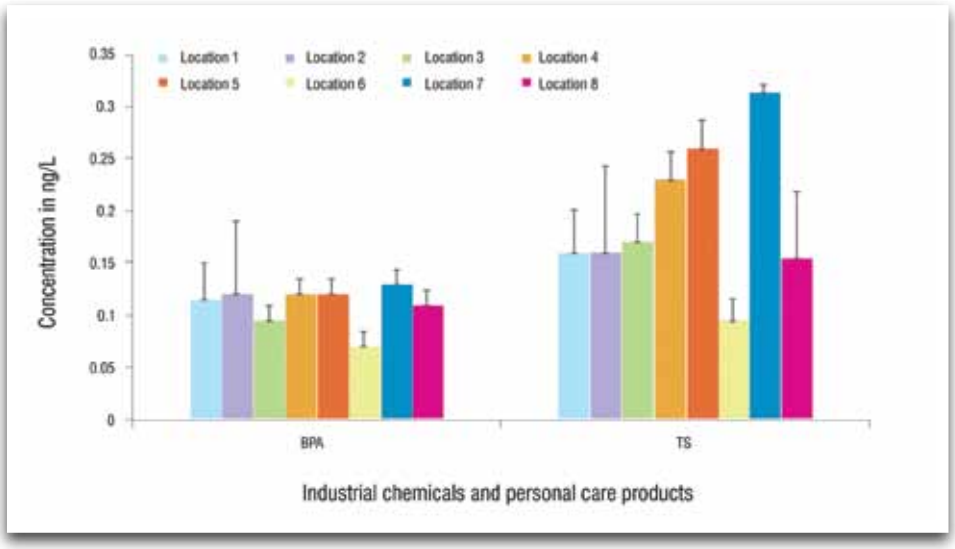
Figure 2: Concentration of perfluorinated compounds in seawater samples collected off Granger Bay, Cape Town.



DSS, diclofenac; SUL, sulfamethoxazole; PHE, phenytoin; CAR, carbamazepine; LA, lamivudine; CA, caffeine; ACT, acetaminophen

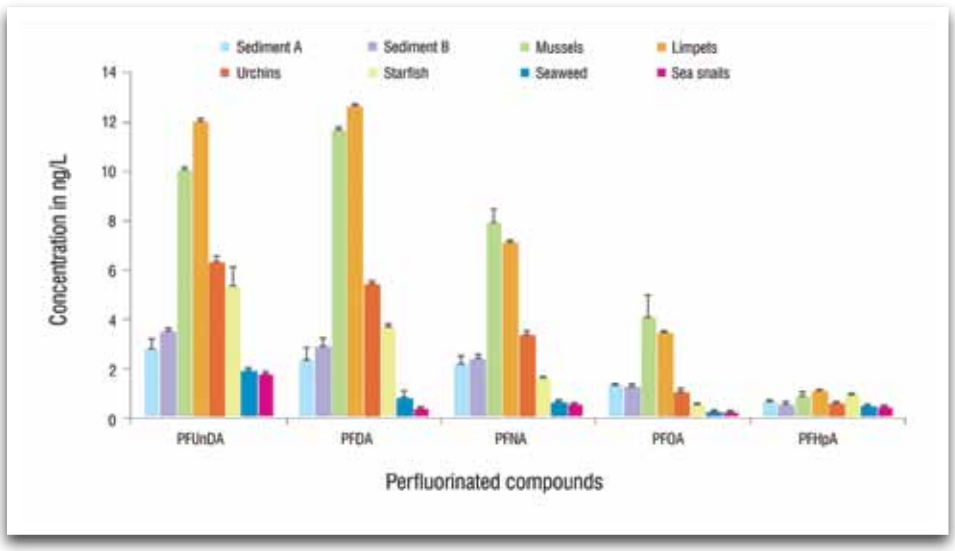
Figure 3: Concentration of pharmaceuticals in seawater samples collected off Granger Bay, Cape Town.

Drinking Water Standard (SANS) 241: 2015), even though Patterton's study demonstrated their presence in South African tap water. Moreover, it is known that disinfectants and antibiotics cause selection for resistance in the gene pool of microorganisms, ultimately making them impervious to the antibiotic or antimicrobial agents. The full impact of constant, low-grade, chronic exposure to



BPA, bisphenol A; TS, triclosan

Figure 4: Concentration of industrial and household chemicals in seawater samples collected off Granger Bay, Cape Town.



PFUnDA, perfluoroundecanoic acid; PFDA, perfluorodecanoic acid; PFNA, perfluorononanoic acid; PFOA, perfluorooctanoic acid; PFHpA, perfluoroheptanoic acid Note: Sediment A is from wet beach sand and Sediment B from where the organisms were found.

Figure 5: Concentration of perfluorinated compounds in marine organisms and sediments from the shores near Granger Bay, Cape Town.

a plethora of pharmaceuticals, antibiotics and cleaning products on marine organisms, the marine food chain, and human health is not yet fully known, but their ubiquitous presence in trace levels in the desalination intake water poses a potential risk to human health.

Although some pharmaceuticals are unlikely to constitute a risk to humans as they are found in low concentrations and have a low toxicity, e.g.such as iopromide, other pharmaceuticals (e.g. natural and synthetic sex hormones) pose considerable risks to the aquatic environment.

Even where seafood accounts for only about 10% of the diet, it has been shown to be one of the main routes by which chemical contaminants find their way into human tissues, which in turn may be deleterious to human health. Moreover, the synergetic effects of pharmaceuticals and other compounds on living organisms are unknown.

Drinking water supplied from the seawater desalination plants should be carefully tested for toxicity, and that need not be costly. Apart from the many compounds present in seawater, industrial effluents as well as hydrocarbon pollution as a result of shipping, pleasure craft and harbour effluents also impact intake water. Natural incidences such as red tide or harmful algal blooms have also been linked to marine sewage outfalls; these could also impact the quality of intake water. As their combined effects and concentrations are mostly unknown, the precautionary principle should be followed with regard to sewage disposal into the environment. Formation of chlorine disinfection byproducts such as inorganic chloramines, organohaloginated byproducts and trichloroamines should also be monitored and removed from the recovered water.

CONCLUSIONS

IMPLICATIONS OF FINDINGS FOR DESALINATION:

Apart from the high microbial load being discharged into the ocean daily, the complexity and toxicity of chemicals that

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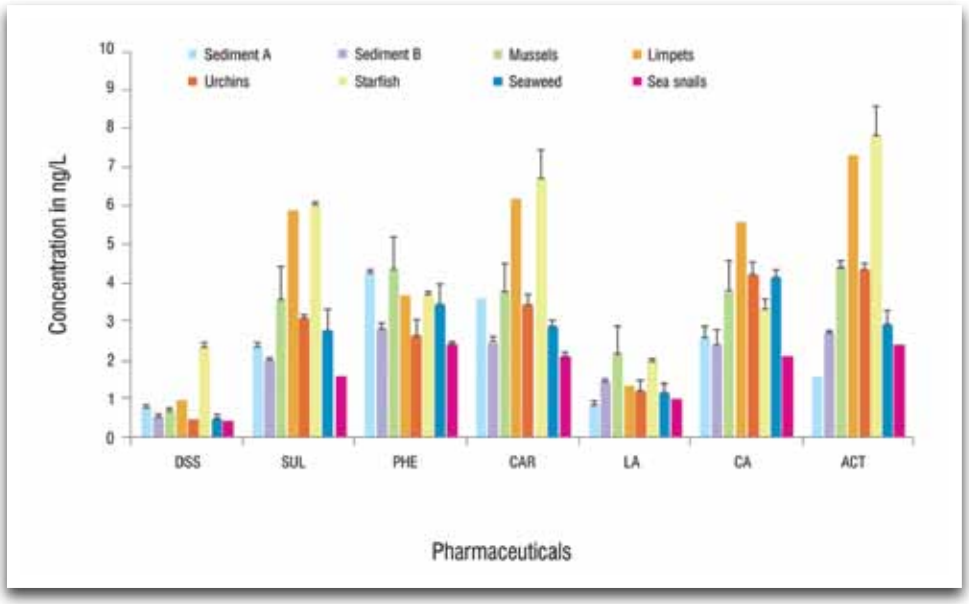
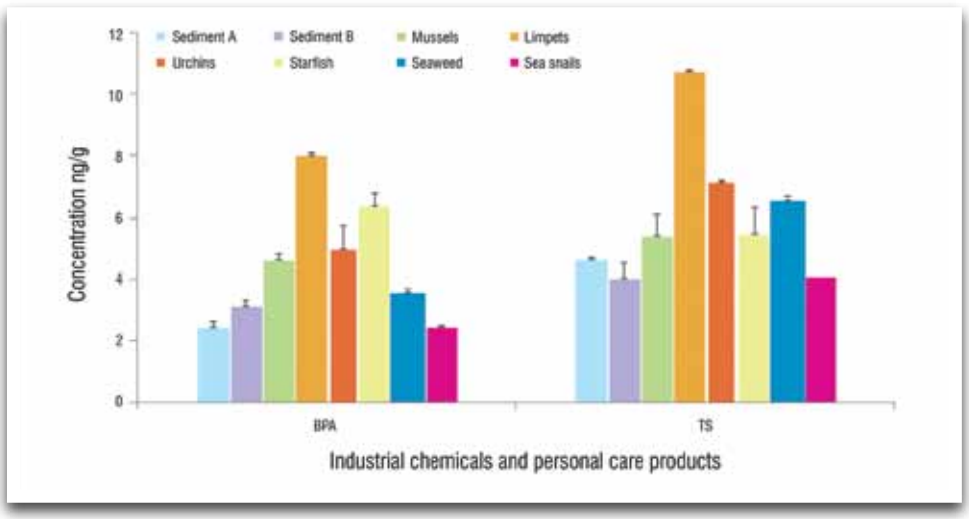


DSS, diclofenac; SUL, sulfamethoxazole; PHE, phenytoin; CAR, carbamazepine; LA, lamivudine; CA, caffeine; ACT, acetaminophen Note: Sediment A is from wet beach sand and Sediment B from where the organisms were found.

Figure 6: Concentration of pharmaceuticals in marine organisms and sediments from the shores near Granger Bay, Cape Town.



BPA, bisphenol A; TS, triclosan
Note: Sediment A is from wet beach sand and Sediment B from where the organisms were found.

Figure 7: Concentration of industrial and household chemicals in marine organisms and sediment from the shores near Granger Bay, Cape Town.

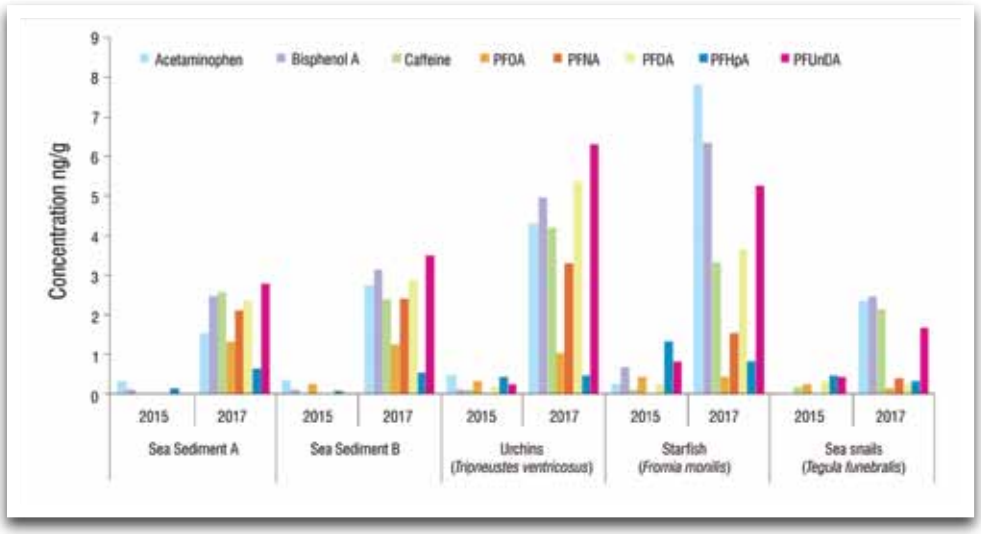
are being disposed into the City's sewage are imposing a growing chemical pollution risk to the nearshore coastal environment, and thus to the desalination plant's intake water.

Given the diversity of contaminants shown to be ubiquitously present in the intake water in such close proximity to the marine outfall in Green Point, it is probable that the water recovered from desalination may still be contaminated with traces of complex pollutants after the reverse osmosis process, as Patterton's study also showed. This probability represents a public health issue.

Drinking water supplied by the seawater desalination plants should be regularly screened for its toxicity. Adequate disinfection and monitoring of the efficacy of tertiary treatment to ensure complete decomposition of harmful pharmaceuticals and other chemicals is essential to ensure that the water supplied to the City is not toxic. Screening for specific compounds is very costly but toxicity tests give rapid results.

Even if most of the compounds were removed by the reverse osmosis step, they are not destroyed and remain in the brine retentate; returning these compounds in the brine retentate to the sea as is planned, only to be filtered indefinitely while toxic compounds build up in marine life, is a futile exercise.

In the long term, it would be technically more efficient and cost-effective to prevent the sewage from entering the ocean in the first place. Moreover, desalination intake water treatment and sewage treatment should include a tertiary stage of combined



PFOA, perfluorooctanoic acid; PFNA, perfluorononanoic acid; PFDA, perfluorodecanoic acid; PFHpA, perfluoroheptanoic acid; PFUnDA, perfluoroundecanoic acid

Figure 8: The difference in the level of selected compounds in marine organisms sampled in July 2015 and July 2017.

advanced oxidation, capable of fully decomposing pharmaceutical compounds. In the best performing wastewater treatment plant for potable reuse of sewage that has been studied in the Western Cape region, the treatment train was composed of a modern dual-membrane treatment process. The membrane system received secondary treated wastewater from a treatment train comprised of a conventional activated sludge treatment process with an optional chemical phosphate removal after chlorination.

The secondary treated wastewater entered the water recovery plant where it was treated using a sand filter, ultrafiltration membrane, reverse osmosis membranes and, finally, with advanced oxidation (including ultraviolet (UV) light) and hydrogen peroxide before being blended with conventionally treated water and distributed. This system currently allows direct potable reuse of sewage and is already operational in the region. This type of system may be able to provide potable water of reasonable quality from wastewater but the water from this well-operated plant was still not passing Ames Mutagenicity and oestrogen mimicry tests for toxicity in our previous study. With a rise in the use of chemical compounds on a daily basis, and many thousands of regulated and unregulated emerging contaminants being discharged and detected in the aquatic environment, many of which exceed the recommended reference dose (mg/kg/day) of various regulators, great caution is needed. Implementation of barriers, monitoring programmes and assessment programmes to eliminate or minimise these risks is essential.

Compact, new treatment systems that can treat the sewage to high standards and recover the water before discharge to the ocean can eliminate the need for desalination. Advanced oxidation systems include ozonation, ozone/hydrogen peroxide, ozone/UV, hydrogen peroxide/UV, UV/chlorine, UV/TiO2, ultrasonic irradiation or sonolysis, photocatalysis, photo fentons, dielectric barrier discharge and electrochemical reactions, which all work by producing short-lived but highly reactive free radicals and have been used most effectively in combined systems for the degradation or destruction of complex organic compounds in water.

A thorough investigation is needed in the Western Cape on viable advanced oxidation technologies to add to the conventional treatment train of coagulation, flocculation, adsorption, precipitation, reverse osmosis, membrane bioreactors, nanofiltration and electrodialysis, recognising that the treatment of sewage and wastes is just as important to public health as the supply of fresh water is.

IMPLICATIONS FOR THE CITY OF CAPE TOWN

The idea of sending a sewer pipeline out to sea was approved when the volumes of effluent being discharged to the ocean were relatively small. This decision was based on the incorrect assumption that 'the solution to pollution is dilution', and at a time when the variety and volume of manufactured chemicals and pharmacological compounds impacting the sewage was far lower than is the current situation.

PIPELINE EXTENSION

These findings demonstrate that the assumptions behind marine sewage outfalls are incorrect and outdated. Extending the pipeline out to sea will not solve the problem, as it is clear that, under certain conditions, sewage flows back to shore in quantities that are harmful. Toxic chemicals will be released, albeit further from the shore, impacting marine life.

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PREDICTIVE MODELLING

Until the sewer outfall is replaced, predictive modelling based on daily weather and sea conditions offers a better tool for seawater quality and beach management than sample-based monitoring. Much of the information that is required for predictive modelling is already being collected daily by ocean users who have set up WindGuru stations or similar, and who would actively participate in a citizen science project. A study consolidating such data with daily water samples is needed.

THE PRECAUTIONARY PRINCIPLE

The measurable presence of indicator organisms and indicator chemicals points to the presence of pathogens and many other persistent chemicals in our ocean. The potential for their bioaccummulation is demonstrated.

Because of the hazards of these compounds, the precautionary principle is highly relevant in terms of human health. Should desalination of seawater be the main option for augmenting potable water supplies, the health risks of pharmacological and chemical compound accumulation need to be quantified by daily monitoring and mitigated prior to the release of the water into the potable water reticulation system. An example of such a monitoring system is the Windhoek Reclamation System. Testing the provided water to South African National Drinking Water Standard (SANS) 241: 2015 is not adequate as these compounds are not yet regulated.

THE 'POLLUTER PAYS PRINCIPLE'

In terms of the 'polluter pays principle', the costs of the chemical and pharmaceutical compound clean-up ought to be borne by the companies producing the substances. Pharmaceutical and chemical companies are among the wealthiest multinational corporations globally. While air polluters are required to ensure emissions are cleaned from the commons that is the air breathed by all, pharmaceutical companies and the chemical industry have not been contributing to the clean-up of pollutants in water systems.

PURCHASING POWER

Retailers and consumers of pharmaceuticals and common household chemicals need to review their contribution to the growing pollution of ocean ecologies. Our individual decisions have a huge collective impact.

POLITICS OF WATER, ENVIRONMENT AND SANITATION

Historically, cities were made possible by the development of infrastructure to adequately manage human waste. The City of Cape Town has outgrown its current water supply and sanitation infrastructure.[54] While the City has vigorously opposed the politics of the 'poo flingers', such as Andile Lili who has dumped human waste to force the argument about improved sanitation in Khayelitsha and elsewhere, the City itself is daily depositing a volume of many Olympic-size swimming pools into the ocean. One might indeed quip that in terms of the current sewage management infrastructure, 'Je suis Andile Lili'. The convergence of sanitation activism in seaside suburbs and shack settlements in a time of drought suggests that the City's water should be understood as one hydrological system, and therefore managed as a single ecology, not via the separation of environment, sanitation and water supply. wn

REFERENCES

If you would like to read the complete paper with references, please send an email to minx@saiee.org.za.

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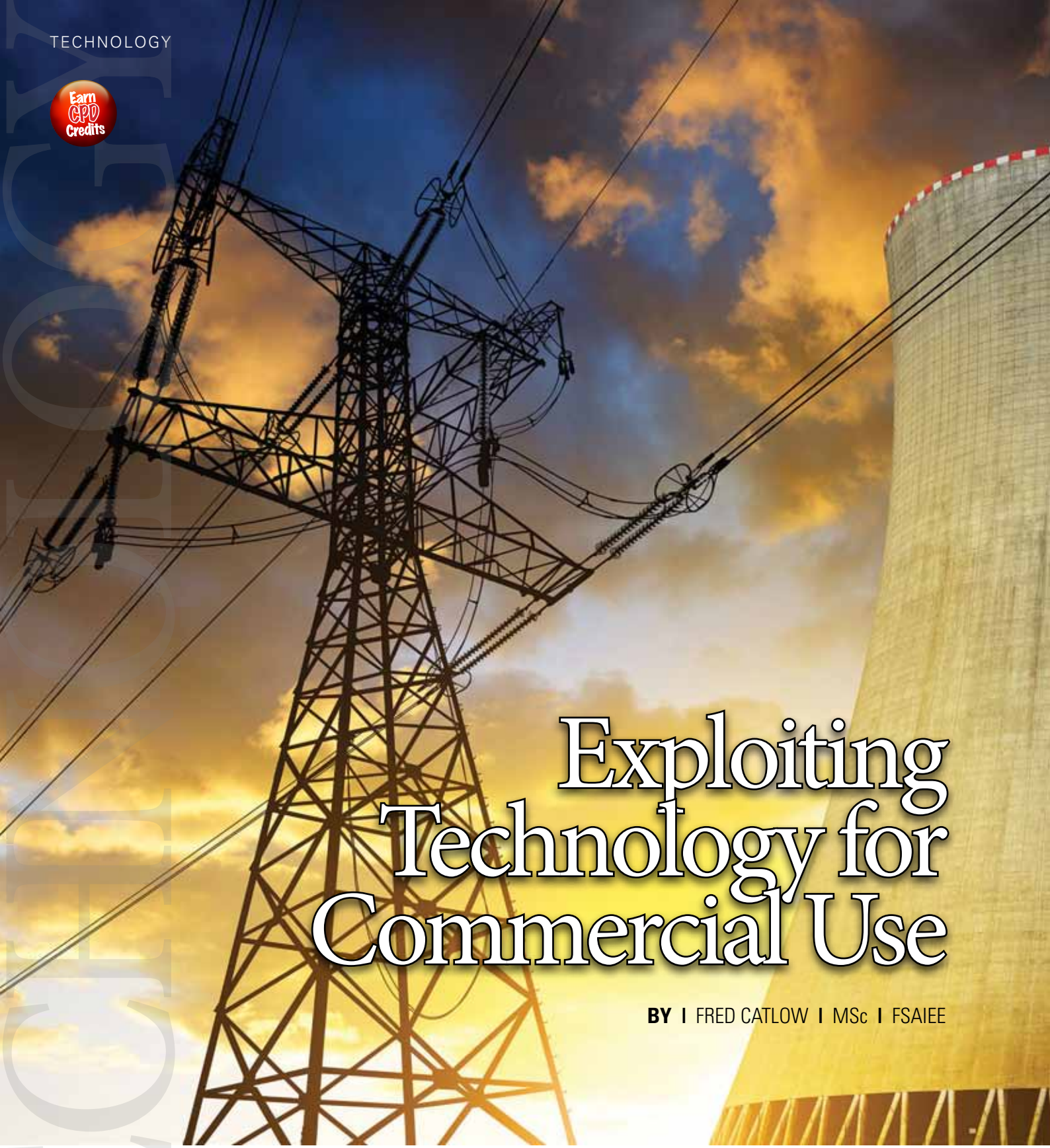

Exploiting Technology for Commercial Use

BY | FRED CATLOW | MSc | FSAIEE

Whilst large commercial nuclear reactors are perceived to have problems, not only of safety but of delays and costly overruns and have had a difficult period over the last thirty years, nuclear submarine reactor technology has an impressive record of safety of more than sixty years in operation. Nuclear reactors have outperformed other types of propulsion for submarines in almost every aspect including endurance. Submarine reactors can remain operative without refuelling for more than 25 years and longer. Such vessels can also remain submerged for extremely

Whilst large commercial reactors are perceived to have problems, not only of safety but of delays and costly overruns and have had a difficult period over the last thirty years, nuclear submarine reactor technology has an impressive record of safety of more than sixty years in operation.

long periods and are only limited by the needs of their crew members.

Although submarines are subjected to rigorous monitoring, for reasons of defence and national security, it would take very little to transform submarine reactor designs to small modular reactors for commercial use.

The major problem would be in designing a reactor that can be factory produced and

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shipped in parts by road, rail or water to be assembled on site.

Small reactors hold enormous promise for the future. Each can produce the output of a small, medium or large windfarm. They would be much more reliable and can operate 24/7 so that their capacity factor can far exceed that of any windfarm. They will be less obtrusive than tall wind turbines, can be used on land or submerged in water and can be made to be extremely versatile.

This paper discusses, the cost per unit of electricity in comparison with other modes of generation, the problems of licensing and of waste disposal.

Abbreviations: PWR - Pressurized Water Reactor; AGR - Advanced Gas Cooled Reactor; SMR - Small Modular Reactor; EPR - European Pressurized Water Reactor; EIA - Energy Information Administration; SNF - Spent Nuclear Fuel; (V)LLW - (Very) Low Level Waste; ILW - Intermediate Level Waste; EROEI - Energy Returned on Energy Invested; H/LEU - High /Low Enriched Uranium; NPT - Non-Proliferation Treaty.

A REVIEW OF NUCLEAR POWER IN 2018

BACKGROUND

Commercial nuclear power began with great promise, promoted by President Eisenhower's "Atoms for Peace" speech at the United Nations in 1953 and many countries mainly in the west, such as the United States, Canada, Britain and the Soviet Union, had their own independent nuclear power programmes. However, the nuclear industry stalled after 1979, following the accident on Unit 2 reactor at Three Mile Island NPS (TMI-2).

The drive for nuclear power is now principally in Asia, especially in China where 38 reactors are now in operation, all commissioned since 1990, with a further 20 under construction and more planned for the future, whereas no new reactors have been built in the USA since the 1990s.

It is 39 years since TMI-2. There were no casualties and one of the the main contributory factors was that the operators were inadequately trained and could not diagnose the not unusual problem of a stuck open pressure relief valve.

Lesser problems were poor maintenance practice, since tags had been left in place on the main control desk, which were obscuring some of the instruments; also lack of a comprehensive method of identifying the initiating problem as the sequencing of events was inadequate.

The fact that the reactor was destroyed, yet there was no significant release of radioactive products into the atmosphere, was vindication of the soundness of the US PWR design and the 'defence in depth' philosophy. Had the operators not panicked and interfered, the reactor would have shut down safely of its own accord.

Others saw the event differently. They saw it as proof that nuclear power was inherently unsafe and that TMI-2 was 'an accident waiting to happen'. The mass media supported by Greenpeace and other nuclear unfriendly organisations spread 'fake news' and promoted mass hysteria among the public through sensationalism, exacerbated by the unnecessary and panic evacuation of Dauphin County, which was described by many residents as a 'nightmare'. The accident had a major impact on the nuclear power industry as a whole. More than 100 new reactors were cancelled, some already under construction, although, this was not entirely due to TMI-2, as cheaper natural gas plants were entering the market and had a detrimental effect on the economics of nuclear power. Confidence in nuclear power was shaken,

The negative attitude towards nuclear power still prevails in some quarters to this day; California and Germany, in particular, have forced viable plants to close and fear has forced the closure of other nuclear installations which are regarded by some as dangerously close to populated areas or human activity. Even in China, demonstrations in Hong Kong greeted construction of the first reactor at Daya Bay.

The negative attitude towards nuclear power has not been helped by accidents at Chernobyl in 1986 and Fukushima Daiichi in 2011.

STAGNATION

Faced with a possible moratorium on new build, many US operators decided that rather than decommission plants at the end of their licensed 40 year operating life, at great expense, they would apply for licence extensions with appropriate upgrades as necessary.

To date, 74 plants have been granted 20 year life extensions with a further 17 under consideration. Subsequent Licence Renewals (SLR) to operate beyond 60 years are currently under consideration, which if agreed, will assure that the US will still have nuclear plants operating beyond 2050.
Notwithstanding the above, EIA are currently predicting a 20% fall in nuclear

output in the United States from 2018 to 2050 even assuming that US plants will obtain the SLR to operate for 80 years lifespan.

The situation in Western Europe is not dissimilar to the United States, with Britain, once a leading nation in the development of nuclear power, abandoning much of its programme, even though the magnox and AGR fleets were performing safely and well and nuclear power stations had rescued the Government from an energy crisis and blackouts during the coal miners' strike of 1984. Likewise, KWU in Germany reduced its activities and Westinghouse Europe in Brussels diverted to other activities. France, alone in Western Europe, continued to promote nuclear power through its Westinghouse licence agreements, buoyed by exports of PWRs to South Africa and China.

RENAISSANCE

A revival of nuclear power was expected during the early years of the 21st century but this was not quite the renaissance hoped for.

The fortunes of nuclear power depend both on national and local politics and on which political party is in power.

Whilst physics and engineering are exact sciences, the decision makers are frequently not conversant with science and engineering and above all are strongly swayed by the voting public which is often ill informed and influenced by myth, fantasy and misinformation not to mention 'downright lies'. Some political parties are nuclear unfriendly, whereas others have a more open mindset. However, the realisation that nuclear power is carbon free and could present a solution to problems associated with global warming and climate change did nurture a more flexible approach during the Bush presidency. After a period of more than 30 years when no new reactors were proposed in the United States, 16 licence applications were made to build 24 new reactors. However, apart from Watts Bar unit 2, which was finally operational in 2016, more than 20 years after construction had been halted, only two new reactors (AP1000s at Vogtle) are planned to be operational by 2021.

Two APRs planned for Virgil Summer have been suspended following the fragility of the finances of Westinghouse Nuclear Electric. Even Vogtle has suffered from delays and cost overruns and is dependent on Westinghouse managing to stay 'afloat'.

However, despite all the problems, the following quotation from the Los Angeles "Business Daily" of 2nd January 2018 is worthy of note: *"But these and other issues swirling around Plant Vogtle obscure the larger point of providing the affordable energy necessary to power Georgia - and the rest of the nation - for future generations. This power plant, once it is operational, will provide some of the cheapest, most reliable power available, for about 80 years. That's four generations of Georgians. Not only will Plant Vogtle provide a stable baseline of power to the electrical grid, it will do so at an affordable consumer cost....."*

"Energy prices are a central concern for many American families, particularly for the millions of senior citizens who live on fixed incomes and benefit enormously from the affordable power created through nuclear energy. It is clean, it is abundant, it is reliable and it is relatively inexpensive...."

"In fact, Georgia Power, which owns and will operate Plant Vogtle, researched a renewable energy approach to provide electricity and found that a solar and battery storage option that could provide comparable amounts of electricity tipped the economic scales at a cost of $25 billion. That figure makes nuclear power look like a bargain".

In Western Europe there are currently three new projects, all French EPRs. Olkiluoto unit 3, in Finland has been an example of how a project can go wrong with everything seemingly going wrong that could go wrong, resulting in bitter disputes between the owner and the contractor. It has been under construction since 2005 and is over budget by nearly three times the original estimate. The start up has been delayed by more than 10 years until 2019.

A similar situation exists on the EPR at Flamanville, France, which is approximately three times over budget and three years behind schedule. The reactors at Taishan are also delayed.

As the first nuclear plant in the UK since Sizewell 'B' was ordered in 1980 (which itself was subjected to a long public enquiry that lasted almost 5 years) the EPR under construction in the west of England at Hinckley is not without controversy as it has been described as the most expensive power station in the world and with a strike price' of £92.50 per MWh, well above the norm.

ASSESSMENT

Overall the future of nuclear in 2018 does not look too promising, at least in the West. Serious delays and cost overruns have damaged the industry's viability and utilities that are pro-nuclear appear to be

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battling against a 'sea of troubles'. False information and untruths, have portrayed nuclear power stations by some, as 'atom bombs about to explode' whilst investors often see nuclear as too risky and prefer to put their money into more profitable projects which offer a quicker return on investment.

To overcome these apparent problems many suggestions have been made as to how nuclear power can be made more acceptable. Many different proposals have been made and new types of reactors are or have been researched with different kinds of fuels, moderators, coolants or none at all.

Advanced revolutionary designs have been proposed. Whatever the outcome, the delicate state of nuclear requires that we proceed with caution and do not repeat the mistakes of the past or make new ones.

Investor confidence in nuclear energy has undoubtedly been unsettled. We should, however, take heart that on the other side of the world things aren't looking quite so disturbing for nuclear power. After a post-Fukushima re-assessment, China is pushing ahead with it's ambitious programme.

Japan just re-started it's sixth reactor, with more to follow, with the realization that nuclear is vital to it's economy, even though they had some very negative feelings after Fukushima.

India is constructing 6 new reactors to add to the 23 'home-grown' ones already in operation (mostly under 300 MW). Korea is working on 4 reactors for the UAR. Turkey commenced construction on the first of 3 plants, Saudi Arabia is planning 16 reactors, and Egypt wishes to commence. In total 50 reactors are currently under construction world wide.

BENEFITS OF NUCLEAR ENERGY

The following factors should be constantly borne in mind:

- Nuclear energy is sustainable.
- It is clean.
- It is reliable.
- It does not emit carbon products.
- It is environmentally friendly.
- It is available 24/7 on demand.
- It is easily controllable.
- Under the control of skilled operators nuclear plants can achieve better than 99% capacity factor and are eminently 'fit for purpose' (unlike many 'renewables').
- Nuclear fuels have a high energy density and thus nuclear power plants only need a small 'footprint' (cf., hydro, CSP & wind) although authorities demand a large exclusion zone, which is often made, at the cost of the owner, into a free public recreational areas.
- A single fuel load can last for long periods, and easily outperforms any other type of fuel.
- The nuclear industry is extremely safe and has one of the best safety records in the world of any human activity.
- Whilst there is a small (unlike coal power) quantity of waste, it can easily be managed and should not be problematic given sufficient resolve to tackle the perceived problem.
- SNF is a valuable asset.
- VLLW can easily be disposed of.
- LLW & ILW can be managed and some can even be 'burned' without ill effects.

According to Joe Grimes, TVA (Tennessee Valley Authority) executive Vice President of Generation and Chief Nuclear Officer, *"Nuclear power remains the only source of carbon-free energy that is available 24 hours a day, seven days a week."*

However, regardless of the fact that in two nuclear accidents, human factors were the underlying cause and in the third a definite contributory factor, the answer to the perceived problems by the authorities has been to apply more more stringent licensing conditions, thereby making nuclear power plants more complicated and more costly to build.

In the author's opinion, the nuclear industry does not extol its many virtues and reacts to criticism in a 'knee jerk' manner by responding to each perceived problem. We need to put things in perspective.

Nuclear energy supplies 11% of the world's electricity. There are 450 operating reactors throughout the world with an accumulated 17,000 years of safe operating experience employing over 1 million people. It is the second source of low carbon fuel behind hydro-electricity. It is the fuel with the greatest potential with an EROEI of 75%.

A single German Wings pilot was responsible for more deaths in 'one mad moment' in 2015, than the entire Nuclear Industry in more than 60 years of operation in 31 countries.

2015 was regarded as a safe year for flying! The previous year, a Malaysian Airways flight disappeared with 239 people on board, all presumed dead.

There were 324 deaths from 18 accidents in 2016 which was regarded as the second safest year. 2017 was regarded as the safest year with 79 deaths. Deaths in the nuclear industry were zero.

Most of the travelling public have no qualms about the additional radiation to which they are exposed when travelling by air or sunbathing on holiday, yet have an unrealistic fear of exposure to nuclear radiation. People still fly, catch trains and drive cars and yet are terrified of anything nuclear – the same science that has saves the lives of millions of people through X-rays, CT scans, MRI, proton beam therapy and radioisotopes! Nuclear medicine can potentially save 3.5 million lives or more annually.

Despite all the efforts to address the perceived problems by proposing new reactor types, the original Westinghouse PWR design, which has been improved over the years, has an enviable proven record when used in submarines.

A SUCCESS STORY

The United States Navy has had a remarkable success in powering it's vessels from nuclear sources.

The idea of using nuclear energy to power a submarine was first proposed by Dr Ross Gunn of the United States Research Laboratory in 1939, and the world's first nuclear submarine, "USS Nautilus" designed and built by Westinghouse Electric under the guidance of Admiral Rickover was finally commissioned in 1954. Since then; *"The Nuclear Navy has logged over 5,400 reactor years of accident-free operations and travelled over 130 million miles on nuclear energy, enough to circle the earth 3,200 times. The nuclear reactors can run for many, many years without refuelling. They Operate all over the world, sometimes in hostile environments, with no maintenance support except their own crew. These reactors can ramp up from zero to full power in minutes, as fast as any natural gas-fired plant."*

According to Dr James Conca, America's Nuclear Navy has the best safety record of any industry in the world.

He says that: *"Thousands upon thousands of people have continuously lived, worked, eaten and slept within a stone's throw of a nuclear reactor for 60 years with no adverse effects at all. Annual radiation doses to Navy personnel have averaged only 0.005 rem/year*

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(5 mrem/year; 0.05 mSv/year), a thousand times less than the Federal 5 rem/year allowed for radworkers."

In summary, no other source of energy can match the safety, performance, endurance and versatility of nuclear reactors for submarine prime movers, especially as once loaded with fuel they don't need refuelling for the 25 – 40 year life of the vessel.

The author believes that submarine reactor technology could benefit other applications such as providing energy for commercial use.

A NEW APPROACH

RESTATING THE FACTS

After nearly 70 years of successful operation, some politicians are unconvinced as to the viability of nuclear power. Of the three major accidents that have occurred during that time, none have had the catastrophic consequences originally predicted by the media and the public:

- At TMI-2 no one was hurt and the design proved to be sound. The utility, General Public Utilities paid the penalty for having not been sufficiently disciplined. They promised to operate the sister plant TMI-1, safely and they have; in 1990/1 TMI-1, was cited as one of the four safest plants in the USA.
- The no. 4 reactor at Chernobyl was a Soviet designed RMBK 1000 which had been identified as having serious flaws and would never have been licensed in the west. However, although the accident was truly terrible with untrained operators performing a possibly illegal, very risky low power test on an operating reactor; a task which involved disarming the reactors safety systems, the death toll is reported as 31 direct deaths (mainly firefighters) and 15 unconfirmed deaths up to 2011. What made it worse was that various simple precautions to protect the people, which are routine in the West, were not taken. Although this was the worst possible nuclear disaster imaginable, there was nothing like the millions of radiation deaths predicted by Greenpeace (after more than 20 years).

  "The Chernobyl disaster was a unique event and the only accident in the history of commercial nuclear power where radiation-related fatalities occurred. ……. it led to major changes in safety culture and in industry cooperation, particularly between East and West before the end of the Soviet Union." - World Nuclear Association

- At Fukushima Daiichi, four BWR reactors (2 General Electric, 1 - Toshiba, 1 - Hitachi) were rendered inoperative in 2011 by an event known as the "Great Tōhoku Earthquake and Tsunami". The owners, TEPCO had ignored warnings that such an event could occur and could cause serious damage, they failed to take sensible precautions such as strengthening the sea defences and protecting their emergency standby generators from flooding. Although, the tsunami was responsible for the deaths of 16,000 people and the countryside was devastated for many miles ripping up railway lines and destroying countless installations, no deaths were attributed to radiation sickness. 100,000 people were evacuated from the vicinity of the power plant, and "Government nervousness" delayed their return, however, *"Official figures show that there have been well over 1000 deaths from maintaining the evacuation, in contrast to little risk from radiation if early return had been allowed"* - World Nuclear Association.

What the above lessons have shown is that although nuclear emergencies must be treated with the utmost care and respect, fear of the effects of a nuclear accident have been grossly exaggerated and have created unnecessary mass hysteria. Fear of exposure to radiation has caused more deaths than radiation itself. Nuclear power is far too important to be ignored or regarded as something to be avoided at all costs. It is a valuable, safe, clean, practical source of energy and should be seen for what it actually is and not some fictitious monster.

STANDARD COMMERCIAL REACTORS

Until now we appear to have adopted the approach the 'bigger the better'. Designers of reactors such as Areva's EPR, doubtless, believe that there are economies of scale. Whilst it is true that one would expect the cost per unit to be comparatively less for a large unit than a small one this does not always appear to be the case, especially as 'front end' problems such as delays, cost overruns and other problems are expensive and will deter investors. Moreover, if all the power from the unit exceeds the demand at any particular time, the output will be below capacity and the power station will not be fully utilised.

Whilst one acknowledges that the French EPR in Finland is the first of a kind, there are a further three units suffering from similar problems and potentially two more units at Hinkley.

These kind of problems tend to give nuclear a bad name and are easily highlighted by the media.

Not dissimilar problems occurred in the past in Britain, through the AGR programme, where although all the front end problems were supposed to have been resolved by building a prototype, WAGR, the Windscale AGR, no lessons seem to have been learned. The various groups of contractors building AGRs did not adhere to the prototype design, there are considerable differences in what were supposed to be identical AGRs, and the costs spiralled almost exponentially.

In France, following the OAPEC oil embargo of 1973, and in the absence of any other viable source of energy, the Government embarked on a large scale programme of building nuclear power stations, based on the PWR Westinghouse design, which they faithfully 'cloned' as part of the licensing agreement. Most of their fleet is based on this design. They now produce their own PWR designs such as the current EPR.

MARINE PROPULSION REACTORS

Whilst the cost of naval reactors is not well known because of the secrecy surrounding defence projects, common sense tells us that small reactors should be cheaper to make than large reactors. They should be cheaper to operate and cheaper to build especially when we are contemplating an existing proven design which has been repeated many times. The lead time between placing the order to commercial operation should also be significantly reduced.

Naval reactors should have the advantage that they can be more manageable and the construction time and costs should be more predictable and less traumatic with fewer surprises, thereby making them more attractive to investors.

A large proportion of the plant can be factory built and tested. They can be shipped to site less piecemeal and the time to erect and test the assembled parts should be significantly reduced.

On average, normal full size power plants of 1GW or more are expected to take between 40 – 60 months to complete from first pouring concrete, although additional time needs to be added for site clearance and final testing during operation. Unfortunately, few large plants currently are built on schedule and such delays are extremely expensive and make nuclear power less attractive to investors.

It should be possible to easily control multiple small reactors from a single control room. If a large unit is out of service the entire electrical supply is lost, whereas when a small unit is out of service the disruption is not so great and capacity is still available. Utilities can control small reactors remotely so that the actual power unit can be located deep in coastal waters or buried in a disused coal mine. This is especially valuable considering that the fuel can last for an extended period.

If it makes sense to connect remote wind and solar generators to the network, the same philosophy should apply to reactors, which, although there are advantages in operating them in groups on licensed sites, they should also be capable of operating individually as well. A case in point is offshore wind. It would seem to be less demanding from a construction point of view to employ offshore submarine reactors, which will be more reliable, occupy less space, require less maintenance, be less damaging to the environment and be cheaper.

The excellent safety record of the US nuclear navy is presumably attributable to a high level of standardisation in naval power plants and their maintenance, and the high quality of the Navy's training program. Service personnel tend to be more disciplined and the owners are not constrained by commercial interests.

SMALL REACTORS

'IF IT WORKS - WHY FIX IT?'

The Westinghouse 10MWt PWR submarine reactor, although modified and updated for present day use, is designed to the same basic principles as the original reactor tested at the Argonne National Laboratory in 1953.

It is smaller and simpler than its sister, the 920MWe reactor used to generate electricity for commercial use in many countries.

Because of space restrictions, submarine reactors are of necessity small and have a higher power density as the fuel is generally more highly enriched enabling the most modern reactor core to have a longer life of up to 40 years without refuelling. Small reactors are used in nuclear powered ships, namely: aircraft carriers, cruisers, destroyers and submarines but also merchant ships and ice-breakers and have shown better performance than other types of marine propulsion. They have greater endurance, versatility, reliability and longer life than other sources of power. *"United States naval reactors are given three-character designations consisting of a letter representing the ship type the reactor is designed for, a consecutive generation number, and a letter indicating the reactor's designer. The ship types are "A" for aircraft carrier, "C" for cruiser, "D" for destroyer, and "S" for submarine. The designers are "W" for*

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Westinghouse, "G" for General Electric, "C" for Combustion Engineering, and "B" for Bechtel. Examples are S5W, D1G, A4W, and D2W", courtesy Wikipedia.

British submarines of the Royal Navy use reactors built by Rolls-Royce up to 100MWe, a PWR design similar to the Westinghouse design but which has developed along a different path although highly dependent on US technology.

Other navies with nuclear powered vessels are China, France, India and Russia.

LICENSING

Whilst the current submarine reactors have been approved by the regulators, the licensing conditions for submarine reactors is, if anything, more stringent than for commercial reactors.

There is, however, a wealth of operating experience so that the risks are extremely small.

Submarine reactors would have to be modified for commercial use but the changes need only be minimal and common sense logic tells us that we would expect the modified design to be approved without any major problems.

The regulatory process is already well advanced for some SMR. However, the overall process could take up to almost 5 years, which the author feels seems excessive. Should we really be applying the same regulatory principles used for large reactors to small reactors of much less power and is it necessary to go through the entire due process for each design, even if there are marked similarities or some parts are identical?

MANUFACTURING

Hopefully, commercial small reactors could be manufactured in the same facilities as naval reactors but if this is not found to be possible due to military restrictions, it should not be a major problem to establish a new identical facility on the same site.

The cost of manufacturing could perhaps be reduced by utilising new techniques such as 3-D printing.

SITING

Small reactors have the advantage that they can be located in coastal waters or buried in the earth, they can also be located at existing licensed sites, especially those where the original reactors have been shut down. Other 'brown field' sites are also possible depending on the local authority and the regulators.

They could be used effectively in very remote off-grid locations, such as the Arctic North of Canada and Alaska, or other remote mining or drilling sites and as stand alone power units for some industrial sites.

They will be still be required to resist seismic shocks but the foundations will not be as onerous as those for large plants. The savings on long transmission lines will make the extra construction costs worthwhile.

ADDITIONAL USES

Apart from electricity generators, potential uses for small reactors are almost endless. These include: source of steam which can be used for a variety of industrial purposes, district heating, hydrogen production for fuel cells, water desalination in places such as Saudi Arabia and other parts of Africa and Asia subjected to drought. An obvious choice is transport, especially marine propulsion.

FUEL

In order to extend the life of the reactors to 30 years, submarine reactors use highly enriched fuel, HEU, which is equivalent to weapons grade and under the NPT agreement is not allowed for civilian use. French and Chinese submarine reactors use LEU which can be up to approximately 20% enriched. They consider this adequate for their needs, although their submarines require to be refuelled more frequently than every 30 years, about every five years.

Under current international agreements LEU would have to be used for civilian commercial reactors and if they have to be refuelled every 5 years, it would still be an improvement on the current 1½ years for large reactors. Standard light water reactors are approximately 5% enriched.

COST CONSIDERATIONS

Until we start using small reactors for commercial purposes we will not know the overall costs.

Nuclear propulsion was thought to be too expensive for the new British aircraft carriers. It was apparently rejected for for a variety of reasons. However, the use of hydrocarbons for transport and diesel power in particular, has been the subject of a great deal of debate recently. Owners of diesel cars in Britain may in time regret their choice.

Many of the front end costs should be less than for large reactors submarine reactors have already been approved by the regulators and the design is tried and tested.

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According to GE Hitachi their new BWRX-300 can produce power for approximately $40 per MWh, which is comparable to China at $49-64 per MWh.

ELECTRICITY SUPPLIES

GLOBAL ENERGY

Currently, approximately 87% of total global energy is from hydrocarbons such as coal, 30%, oil & petroleum, 33%, natural gas, 24%. Of the remaining 13%, 9% is from alternative energy ('renewables') of which approximately 6.3% is from hydro-electricity, wind, 1.35%, biofuels, 0.72%, solar, 0.36% and the remaining 0.18% is from other; only 4% is nuclear.

For electricity production only, The statistics are different with thermal generation 78% of which approximately 67% is from carbon fuels; 11% nuclear and 22% percent renewable energy of which approximately 16% is hydro.

Although the percentage of coal utilised is slowly declining, new build coal is still taking place in the developing nations, especially China (and even Germany). It is likely that we will still be using a large percentage of coal for the next 100 years and beyond, if not in the West, almost certainly in the East.

However the continued use of coal is a health hazard in cities, although in the country, the additional carbon is good for crop yields. In order to remain competitive, the West will need a source of energy that is cost competitive with coal and for base load power, nuclear is probably the only source of energy capable of filling that role.

Panic moves to eliminate dependency on carbon fuels, should be avoided and a gradual replacement is required without causing sudden disruption.

Increased use of wind, solar and other 'natural' resources could provide a supply problem as due to their unreliability, 'spinning reserve' back up is required to maintain supplies of electricity which invariably use hydrocarbon fuels, however, this is an area where small reactors could provide low carbon load following capability and complement wind and solar, although one could ask the question why not just use nuclear in the first place.

COST COMPARISONS

Statistics produced by Lazard show that the cost per MWh of electricity from alternative energy sources is steadily falling and becoming more competitive, even comparable to Gas Combined Cycle which is benefiting from the exploitation of shale gas through 'fracking'. However, as they point out that: *Although alternative energy is increasingly cost- competitive and storage technology holds great promise, alternative energy systems alone will not be capable of meeting the baseload generation needs of a developed economy for the foreseeable future. Therefore, the optimal solution for many regions of the world is to use complementary conventional and alternative energy resources in a diversified generation fleet."*

At the introduction to their November 2017 they point out that certain factors have not been included such as:

- capacity value versus energy value
- costs related to distributed generation
- network upgrade
- transmission or congestion costs

Capacity factor is an important consideration since whilst the renewable capacity is steadily increasing it was reported in the UK 'Daily Telegraph Business' section dated 26th October 2016 that: *"Solar surge sees renewable power capacity overtake coal"* The article claimed that global capacity of renewable energy was 1,985GW as opposed to 1,951GW for coal.

However, it subsequently stated that coal plants produced approximately 40% of total electricity whereas renewable sources only produced 23% - approximately half, undoubtedly a factor that must be taken into account when considering the unit price of electricity. This highlights the importance of delivered power as opposed to installed capacity since the purpose of power plants is to deliver electricity.

According to the World Nuclear Association [38]; *"Nuclear competes well with rival generation technologies as is indicated by the assessment of the Organisation for Economic Cooperation and Development (OECD) - Nuclear Energy Agency (NEA) & IEA2, although the level of competitiveness does vary at different discount rates and between countries. In the pivotal Chinese market, nuclear has a lower levelised cost of generating electricity (LCOE) than any other technology barring hydro."*

From the author's observations, wind, CSP and biofuels are 'land hungry', an asset which is continuously under threat due to the expanding population and the need for housing and food.

As previously mentioned, renewables also require 'back up' power either in the form of storage or spinning reserve.

SMALL NUCLEAR

Unlike renewables, small nuclear

installations will not need back-up power as they can operate independently, as submarine technology has proved. In fact in remote areas they need not be connected to the grid.

Elimination of transmission and distribution costs will make a considerable saving and make stand alone nuclear more attractive.

In the early days, most municipalities in Britain had their own independent power station many of them generating direct current electricity which was initially used to replace gas as a source of lighting. The quality of the supply was improved by using alternating current which enabled power to be transformed to different voltages and allowed transmission over greater distances, hence the National Grid was born.

Even so, dedicated lines to remote rural and coastal communities and other installations is generally much more expensive than in large urban areas and may need to be boosted. If the cost is too high, remote farming communities, frequently invest in 'stand alone' diesel generators.

Small reactors may prove to be a viable solution if licensing problems can be overcome. Nor are small reactors dependent on the weather. They are more reliable, more environmentally friendly, occupy much less space, don't kill birds, and are less dangerous, quieter and less obtrusive than groups of wind generators.

CHOICE OF FUEL

ENERGY

Nuclear is an energy that never fails. It is always there on demand and although we have yet to improve and develop the way we use nuclear energy, money spent on nuclear research would be far better than spending money on other technologies that will only be temporary or lead to a 'dead end'.

At the present time, we are spending large sums of money, on researching the storage of 'renewable' energy in the form of batteries, yet nuclear fuels have already done the job for us and the name "U-Battery" has even been commercialized. Further, if we haven't yet got to the stage of nuclear powered cars we can, at least, use nuclear energy to produce hydrogen fuel cells, a superior option to electric batteries.

Whilst coal and other hydrocarbons already have stored energy and are easily controllable, they pollute. They have been responsible for the deaths of many, not only through mining accidents but through respiratory diseases.

Nuclear has stored energy and is easily controllable but is clean and much safer than coal. Nuclear waste is only a hazard if it is managed irresponsibly.

Even uranium mining is much cleaner now, as newer methods of extraction by chemical leaching have been developed. The author is not convinced that researching carbon capture storage to provide 'clean coal' is a worthwhile exercise.

SUMMARY

To summarize, despite the enormous promise of nuclear power, 2017 was not a good year. The USA which claims 33% of global nuclear generated electricity has seen its nuclear fleet steadily decline and now only has 99 pre-1980s reactors in operation. Applications for new facilities are under consideration although few have been transformed into contractual obligations. Investors frequently prefer oil or gas plants which are easier to construct and provide a quicker return on investment. Renewable energy plants are also quicker and cheaper to build than nuclear and are often favoured by investors but the actual power delivered in most cases falls short of expectations.

If nuclear plants, which are carbon free and non-polluting, and whose average capacity factor can be 90% or above, received the same government subsidies as renewable energy this would change the whole scenario completely. Alternatively, and preferably, the author feels that renewable energy should not be subsidized and should be allowed to compete on a 'level playing field', especially since it is no longer a new technology.

Nuclear power power stations have served us well over a period of more than 60 years with little or no detrimental effect on human health. Unfortunately, more stringent regulations and licensing requirements make new plant very expensive to build and because of long lead times are not always seen as an attractive investment since return on capital outlay is problematic. Moreover, economies of scale have seen power reactors grow from about 3GW thermal to about 5.25GW thermal. As a result each time we embark on a 'first of a kind' design there are always new problems, approval and licensing delays, construction delays, rectification of unforeseen difficulties. Whilst large units have their merits, if only very few of a particular design are produced, they may not be a good investment.

The Westinghouse 3-loop 900MWe PWR was a design that was produced many

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times throughout the world, recognising that modifications were undoubtedly made on some plants. To a lesser extent the GE BWR also had the advantage of producing numerous plants of the same design, although, there were oversights by TEPCO, the owner of Fukushima.

Small reactors whilst not having the advantages of scale can be competitive with other energy supplies and have the advantage of versatility and flexibility. They can be factory produced and use well tried construction methods so that after the first few units there should be no surprises. In addition multiple units on the same site can be more evenly matched to the demand.

Maintenance could be much improved since the maintenance crews should be smaller for a small reactor than a large one and the same crew can be used to maintain several reactors, moreover lengthy refuelling and maintenance outages when the entire supply is unavailable should be a thing of the past.

CONCLUSION

POTENTIAL FOR SMALL REACTORS

By comparison the promotion of small reactors promises a unique investment opportunity with shorter pay back periods and higher returns on investments.

PRESENT

Large nuclear power plants are here to stay and will be part of the energy mix for many years to come. However, Small reactors also have an important role to play.

Naval PWR reactor technology is a proven technology which is available now, the technology is well known and is licensable, all that needs to happen is for government to approve its application for commercial use (without long bureaucratic delays} even if that only applies to LEU designs which are no longer used by the navy.

New reactor types which are currently being researched and tested can be introduced when they are sufficiently mature for commercial application and been cleared by the regulator. Some of these are already undergoing the acceptance procedures.

INTERIM FUTURE

Work is currently proceeding on small modular reactors, SMRs, in many countries and positive steps are being taken to employ them.

Whilst there should be no problems building them on licensed sites there could be problems convincing the authorities that they are safe to use on remote locations. It will be of enormous benefit to replace diesel generators with small reactors at remote locations such as the Arctic north of Canada.

It will make a huge difference not only to the remote communities but also to the advancement of mining operations.

Scientific missions to Mars are on the agenda for the not too distant future and to make such a mission feasible, a reliable source of power will be required.

We have already seen how the ESA Rosetta Missionfailed to complete its objectives by depending on solar power, which proved to be unreliable. It would be fatal for astronauts lives to be at risk in such a situation.

Explorers will require a source of energy which is 100% trustworthy and with this in mind NASA are prototyping a small light weight reactor which can support human beings on Mars for sufficient time to complete their mission successfully.

LONG TERM FUTURE

For the longer term we can research the use of alternative radioactive fuels and nuclear fuel cells.

The GPHS-RTG unit as used for the Cassini space mission offers immense opportunities for future research and the possibility of using gamma-voltaic technology to micro modular reactors. The ultimate would be to supply self contained individual units so that transmission lines and even the grid could be eliminated altogether. I think it is important to restate the obvious; that nuclear energy is the key to our future. wn

REFERENCES

If you would like to read the complete paper with references, please send an email to minx@saiee.org.za.

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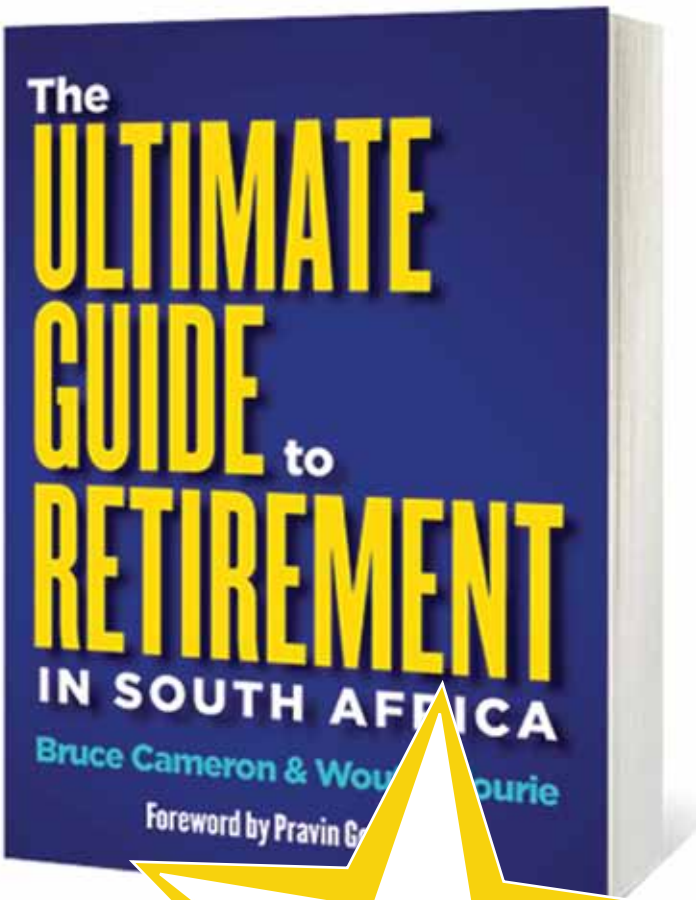

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Gravitational Velocity

The first breakthrough in an understanding of the nature of gravitation came with Einstein's theory of General Relativity in 1915.

BY | DUDLEY BASSON

Sir Isaac Newton (1643-1727) showed in July 1686 that the gravitational force between two objects could be simply calculated from the formula:
$F = G m_1 m_2 / r^2$.

This however gave no indication as to why or how remote objects could attract each other. Scientist Christiaan Huygens (1629-1695) thought the theory absurd, as how could the one object even know that the other object is there.

Newton was the first to consider, in his Principia, an extended expression of his law of gravity to include an inverse-cube term of the form:

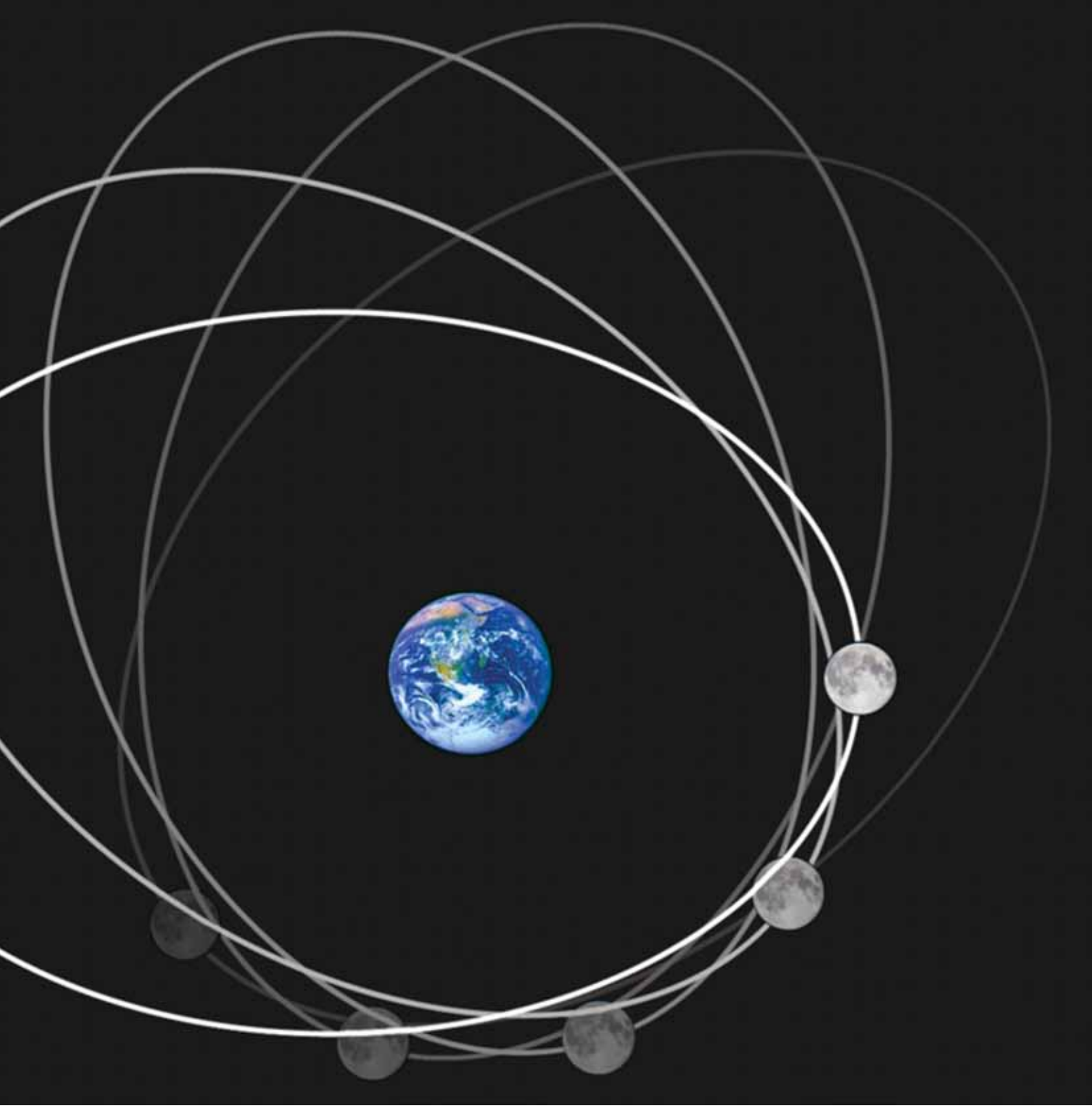
$$F = G m_1 m_2 / r^2 + B m_1 m_2 / r^3$$

attempting to explain the Moon's apsidal motion. The lunar apsidal motion takes 8,85 Earth years to move full circle. Astonishingly, this was discovered by the ancient Greek astronomer Hipparchus and accounted for in the Antikythera mechanism. The Moon also has a nodal precession and an axial precession which take 18,6 years.

The Earth has a nearly circular orbit with an eccentricity of only 0,0167. The aphelion is 152,10 x 106 km, perihelion is 147,10 x 106 km and the orbital speed is 107 200 km/h.

New scientific research, based on geological evidence, confirms claims that the orbit of the Earth changes from nearly circular to 5% elliptical every 405 000 years. This is thought to be due to complex interplay with the gravitational influences of Venus and Jupiter.

Newton was himself deeply uncomfortable with the notion of "action at a distance" that his equations implied. In 1692, in his third letter to theologian Richard Bentley, he wrote: *"That one body may act upon another at a distance through a vacuum without the mediation of anything else, by and through which their action and force may be conveyed from one another, is to me so great an absurdity that, I believe, no man who has in philosophic matters a competent faculty of thinking could ever fall into it."*



Newton's law implied that every particle in the universe was attracted to every other particle, despite of it being patently absurd to suggest that an atom in one galaxy can be attracted to an atom in another galaxy. Gravitation does however function cumulatively and galaxies do indeed attract each other.

Newton's second law of motion states that the force required to accelerate an object is proportional to the inertial mass, given by the formula:

$$F = m\,a$$

There has been speculation that inertial mass and gravitational mass might be different quantities, but general relativity requires them to be identical.

When a small planet is in a circular orbit around a large star then the centrifugal force is exactly balanced by the gravitational attraction, or rather the gravitational acceleration matches the orbital

Gravitational Velocity

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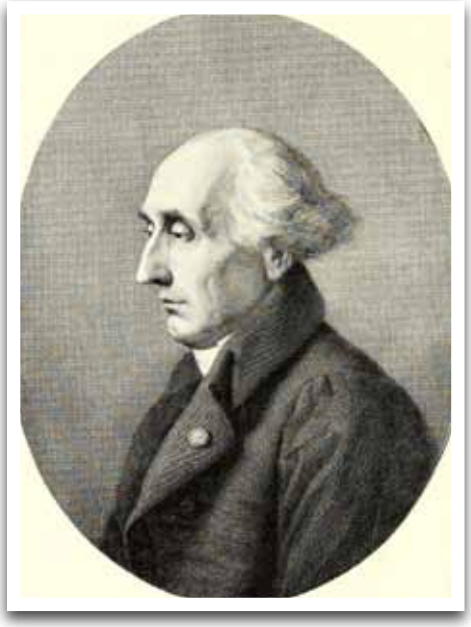
acceleration. Objects near or on the Earth experience a gravitational acceleration 'g' which if resisted gives the weight of the object:

$$W = m\,g$$

The value of 'g' at the surface of the Earth is taken as 9,80665 m s^{-2} but this can vary from 9,7640 m s^{-2} to 9,8340 m s^{-2} depending on location.

Newton's Gravitational Law, however, worked well, and showed that a planet orbiting the Sun would move in an elliptical or circular orbit, if the Sun had a very much larger mass than the planet. In general, a small object moving near a large sun would have a conic section path (circle, ellipse, parabola, hyperbola). If two objects with significant masses orbit each other, they will orbit as a binary system about the barycentre of the two masses. Binary stars orbiting each other are quite common. In the case of planet Jupiter, the barycentre of the orbit is nearly 5000 km above the surface of the Sun. In the case of the Earth and its moon, they will also orbit their barycentre so that the Earth's path about the Sun will be elliptical with a wavy component. The Earth-Moon barycentre lies inside the Earth at 4671 km from the centre. The Sun-Earth barycentre lies 449 km from the centre of the Sun.

If a third object is added to the system things get horribly complex. For a general three body orbiting system there is no analytic solution possible. A multi-body system can have unstable aperiodic orbits with chaotic movements and collisions, and can even expel bodies from the system. The system can however be greatly simplified if movement is confined to a single plane. Newton despaired saying:



Joseph Louis Lagrange (1736-1813)

Pierre-Simon, marquis de Laplace (1749 - 1827)

"This exceeds, if I am not mistaken, the force of any human mind."

In 1887 King Oscar of Sweden and Norway, celebrating his 60th birthday, announced a competition for the solution of the three body problem. Mathematical genius Henri Poincaré attempted to solve the problem and made great advances in celestial mechanics.

Mathematician Weierstrass, on awarding the prize to Poincaré declared: *"This work cannot indeed be considered as furnishing the complete solution of the question proposed, but that it is nevertheless of such importance that its publication will inaugurate a new era in the history of celestial mechanics."*

The famous mathematician Joseph Louis Lagrange (1736-1813) also attempted the three body problem, and discovered the five Lagrangian points of a planetary orbit, where small bodies could remain in place while orbiting as a whole with the planet. The Lagrangian points of an orbit are of vital importance to space missions. The first three Lagrangian points were discovered earlier by Euler.

Pierre-Simon, marquis de Laplace (1749 - 1827) is regarded as one of the greatest scientists of all time. He did important work on the development of mathematics, statistics, physics and astronomy. He summarised and extended the work of his predecessors in his five-volume Traité de Mécanique Céleste (1799–1825). This work translated the geometric study of classical mechanics to one based on calculus.

The famous Scottish scientist and mathematician Mary Somerville (1780-1827) translated Laplace's Mécanique Céleste into English as *"The Mechanism of the Heavens"* explaining the mathematics of Laplace which was not well understood in England at the time. Laplace remarked that Mary and Caroline Herschel* were the only women who ever understood his work.

* *German Astronomer*

He formulated Laplace's equation, and pioneered the Laplace Transform which appears in many branches of mathematical physics, a field that he took a leading role in forming. The Laplacian differential operator is widely used in mathematics. He restated and developed the nebular hypothesis of the origin of the Solar System and was one of the first scientists to postulate the existence of black holes and the notion of gravitational collapse.

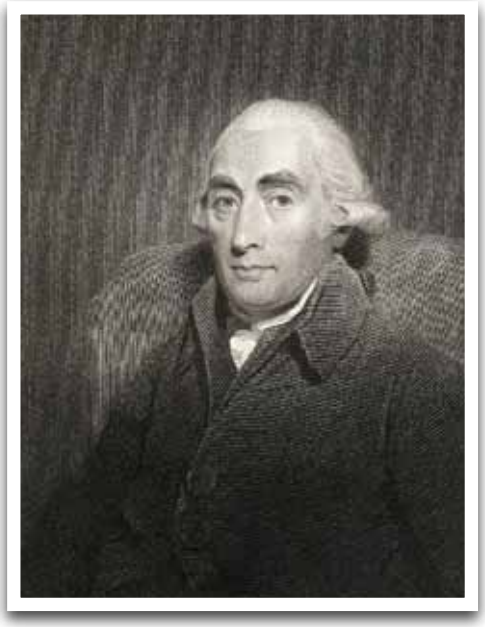
Laplace did early work on orbital resonances studying the linked orbits of the Galilean moons of Jupiter. This fascinating topic shows how planetary and moon orbits can gravitationally influence each other to take orbital periods which are in simple integer ratios with each other. This also influences the wide spacing of orbits.
More on this topic can be found at: https://en.wikipedia.org/wiki/Orbital_resonance

Calculations of solar system orbits are however greatly simplified by the huge mass of the Sun, the comparatively small planets and the wide spacing of the planetary orbits. When precise calculations are required it is necessary to take into account the influence the planets have on each other and the orbital perturbations that they cause. Perturbations of planet Uranus led Urbain Le Verrier in Paris and John Couch Adams in Cambridge to separately calculate the nature and position of an unknown planet perturbing Uranus. This was found as predicted and named Neptune.

Another influence on orbits can be caused by tidal bulges in the planets and moons. The Earth's moon has lost its original rotation and is in tidal lock with the Earth, always presenting the same face to the Earth. There is however a small oscillation in the face presented which is known as a libration. Tides in orbiting bodies result in a slow loss of energy. The Moon was originally very much closer to the Earth than it is now and the distance continues to increase at 3,8 cm per year.

Friedrich Wilhelm Bessel (1784-1846)

Friedrich Wilhelm Bessel (1784-1846), Astronomer, Mathematician, Physicist and Geodesist made a major contribution to astronomy by developing a method of determining the distances to stars by using parallax, and the Earth's orbit as a baseline. This introduced the distance unit 'Parsec' (Parallax arc second) equal to 3,26156 light years. Every student of engineering or physics will be familiar with the advanced mathematics of Bessel functions, which are in widespread use and are also applicable to planetary perturbations. In order to make use of Newton's gravitation formula it was necessary to have an accurate value for the gravitational constant 'G'.



Henry Cavendish (1731-1810)

Henry Cavendish (1731-1810) was the first scientist able to measure the gravitational attraction between physical objects in laboratory conditions. In 1797-1798, following on from work of previous scientists, he performed his famous Cavendish Experiment which used a torsion balance to measure the attraction between lead balls. The apparatus was housed in a wooden chamber which protected the delicate apparatus from air currents and temperature changes. Two 0,73 kg balls were attached to the ends of a 1,8 m torsion balance arm which was suspended by a torsion wire. Two 158 kg balls were held in place by a separate suspension system. By measuring the slight deflection of the beam Cavendish was able to determine the attraction between the pairs of balls. He was able to measure the deflection by observing Vernier scales through telescopes projecting through the sides of the chamber. He announced his result by giving the density of the Earth as 5,4480 ± 00,033 times that of water. This

Gravitational Velocity

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then gave the mass of the Earth and a value of Newton's gravitational constant 'G'.

The present CODATA value of 'G' is $6{,}67408\times10^{-11}m^3kg^{-1}s^{-2}$ which differs by only 1% from Cavendish's value. The equipment was remarkably sensitive for the time. The twisting force exerted by the wire was extremely small: $1{,}74\times10^{-7}$ N at the beam ends which was about 1/50 millionth of the weight of the small balls. The period of the beam oscillation was about 20 minutes and the amplitude at the ends 4,1 mm.

Cavendish is also famous for the discovery of hydrogen, which he called 'inflammable air'. The gases hydrogen (water maker) and oxygen (acid maker) were named by Lavoisier. Both oxygen and hydrogen can reasonably be called 'water maker' but oxygen is poorly described as 'acid maker'. To interchange the names of these gases would now be unthinkable.

Cavendish made several remarkable scientific discoveries which went unpublished. On reading through Cavendish's manuscripts, James Clerk Maxwell found these discoveries that had been later re-discovered by other scientists. Some historians have suggested that Henry's reclusiveness and extreme shyness of women were due to a mild case of an autism spectrum disorder, formerly known as Asperger's syndrome.

Henry inherited the vast Cavendish family fortune which made him one of the wealthiest persons in Britain at the time. His father, Lord Charles Cavendish, was the third son of William Cavendish, the second Duke of Devonshire.

The Cavendish laboratory at Cambridge University, opened in 1874, was endowed by William Cavendish, 7th Duke of Devonshire and Chancellor of the University. James Clerk Maxwell founded the laboratory and became the first Cavendish Professor of Physics.

Up until the time of Einstein's Theory of General Relativity, it was thought that the effect of gravitation was instantaneous. If the propagation of changes in gravitational attraction did take time, this would not be noticeable in planets with nearly circular orbits. However in elliptical orbits a time delay would cause a slight precession (apsidal motion) in the orbit. The only Solar System planet with an orbit in which this effect could be noticed is the planet Mercury. It was calculated that the perihelion of Mercury should advance by 5600 seconds of arc per century relative to Earth (or 574,10±0,65 arc seconds per century relative to the inertial International Celestial Reference Frame) due to gravitational effects from the other planets. The measured advance was found to be 5557 seconds of arc. This discrepancy of 43 seconds of arc was precisely accounted for by Einstein's General Relativity.

Photons are without mass and cannot experience gravitational acceleration, yet they will appear to accelerate towards massive objects in exactly the same way as if they did have mass. If photons did have mass it would be impossible for them to travel at the speed of light. In 1917 this effect was required by Einstein's *Principle of Equivalence* which forms part of the General Theory of Relativity.

With the aid of mathematician Marcel Grossmann, he found out how to write physical laws in a form that is valid for any choice of coordinates, by a method involving the use of general tensor analysis. General relativity is formulated completely in the language of tensors. Tensors were introduced by Hamilton but tensor calculus was developed around 1890 by Gregorio Ricci-Curbastro. In 1900 Tullio Levi-Civita and Ricci-Curbastro published a theory of tensor calculus in *"Méthodes de calcul différentiel absolu et leurs applications"*, which Albert Einstein used as a resource to master tensor calculus. In 1933 Levi-Civita made a contribution to Paul Dirac's equations in quantum mechanics.

In 1936, receiving an invitation from Einstein, Levi-Civita travelled to Princeton, United States and lived there with him for a year. When the risk of war in Europe again arose, he returned to Italy where he was deprived of his professorship and membership of scientific societies. When asked what he liked best about Italy, Einstein replied: *"Spaghetti and Levi-Civita"*.

Readers who feel discouraged by seriously advanced mathematics can take comfort in the words of Einstein in a letter to Levi-Civita: *"I admire the elegance of your method of computation; it must be nice to ride through these fields upon the horse of true mathematics while the like of us have to make their way laboriously on foot."*

A famous prediction resulting from General Relativity was that light from a star would be very slightly bent when passing by the surface of the Sun. In 1704 Isaac Newton suggested that light could be deflected by gravity.

Sir Arthur Eddington (1882-1844) was one of the first physicists to understand

the early ideas of Einstein's relativity. On 29 May 1919 Sir Arthur performed observations of the solar eclipse on the island Principe. Unfavourable weather conditions and other problems would have wasted the opportunity had Sir Arthur not taken the precaution of arranging duplicate observations to be taken elsewhere. He managed to record the bending of starlight in the vicinity of the Sun thus proving Einstein's theory. The theory has subsequently been proven many times over.

In 1923 Sir Arthur wrote his *"Mathematical Theory of Relativity"* which Einstein described as: …the finest presentation of the subject in any language. The energy source of the stars remained a mystery for millennia until Sir Arthur proposed that: *"Probably the simplest hypothesis … is that there may be a slow process of annihilation of matter"*.

It is not necessary to wait for an eclipse to see the effect of gravity on light. This phenomenon is also observable in what has become known as gravitational lensing.

If two stars are exactly in line with the Earth and one of the stars is about midway between, then the furthermost star will appear as a ring of light around the nearer star due to the gravitational bending of the light. This phenomenon can also be observed when viewing entire galaxies.

An interesting incident occurred in 1913 when Max Planck visited Einstein who told him of the current state of his work on the theory of General Relativity. Planck replied: *"As an older friend I must advise you against it, for in the first place you will not succeed, and even if you succeed no one will believe you"*.

CONSTANT	VALUE	BASE UNITS
C_0 Velocity of light in space	2,997 924 58 x 10^8 m/s	m s^{-1}
ε_0 Electric permittivity of space	8,854 187 817 x 10^{-12} F/m	s^4 A2 m^{-3} kg^{-1}
μ_0 Magnetic permeability of space	4π x 10^{-7} H/m	s^{-2} A^{-2} m kg

In Maxwell's epoch making mathematical theory of electromagnetic radiation, he showed that the velocity of light in space, the electric permittivity of space and the magnetic permeability of space are related by:

$$c_0^2 \varepsilon_0 \mu_0 = 1$$

These three parameters now have exact values. C_0 is not a dependent variable, it is a fundamental constant of the universe. The value of C_0 is exact as the metre is now defined by the speed of light and μ_0 is exact due to the definition of the ampere. It may seem preferable to regard the coulomb as a base unit rather than a derived unit, but the ampere (coulombs per second) lends itself better to practical definition.

Einstein's Special Theory of Relativity declared in 1905 that the velocity of light applied as a maximum to any transfer of information in the universe and that objects with mass would necessarily travel slower than this. It would take more than a century before it could be experimentally proven that gravitational waves existed, and propagated at the same velocity as that of light.

The double proof came as a sensational scientific breakthrough on 17 August 2017 when gravitational waves were detected (for the 5th time) and were accompanied by electromagnetic waves from the same cataclysmic kilonova event, after propagating for 130 million years.

The currently operational gravitational observatories have been briefly described in the July 2016 issue of **watt**now.

It is hoped that observations at the South Pole station using BICEP3 and the Keck Array will be able to detect gravitational waves by observing polarisations in the microwave background radiation, but as yet no conclusive results have been found. Results thus far have been thwarted by dust within the Milky Way galaxy.

China's gigantic 500 metre radio telescope FAST discovered a radio millisecond pulsar (MSP) coincident with an unassociated gamma-ray source in the Fermi Large Area Telescope (LAT) point source list. Keija Lee, scientist of the Kavli Institute of Astronomy and Astrophysics of Peking University in Beijing declared: *"This discovery demonstrated the great potential of FAST in pulsar searching, highlighting the vitality of the large aperture radio telescope in the new era"*.

The Fermi Large Area Gamma Ray Space Observatory was launched by NASA on 11 June 2008.

FAST, operated by the National Astronomical Observatory of the Chinese Academy of Sciences, has so far discovered more than 20 new pulsars. The first MSP discovery was made by FAST on 27 February 2018 and later confirmed by the Fermi-LAT team in reprocessing of Fermi data on 18 April 2018.

Gravitational Velocity

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FAST - China's 500 metre radio telescope

A Pulsar Timing Array (PTA) is a set of pulsars which is analysed to search for correlated signatures in the pulse arrival times. There are many applications for pulsar timing arrays. The most well-known is to use an array of millisecond pulsars to detect and analyse gravitational waves.

Such detection would result from a detailed investigation of the correlation between arrival times of pulses emitted by the millisecond pulsars as a function of the pulsars' angular separations.

The Pulsar Timing Array (PTA) attempts to detect low-frequency gravitational waves from merging supermassive black holes using the long-term timing of a set of stable millisecond pulsars. The newly discovered pulsar, was confirmed through timing of gamma-ray pulsations. This discovery is the first result from the FAST-Fermi LAT collaboration.

George Hobbs, scientist of the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia and member of the Gravitational Wave International Committee (GWIC) declared: *"The international radio-astronomy community is excited about the amazing FAST telescope, already showing its power in these discoveries. FAST will soon discover a large number of millisecond pulsars and I am looking forward to seeing FAST's contribution to gravitational wave detection".*

GAIA, ESA's magnificent space mission, launched in 2013, to produce a 3D map

of a billion astronomical objects has been producing sensational results.

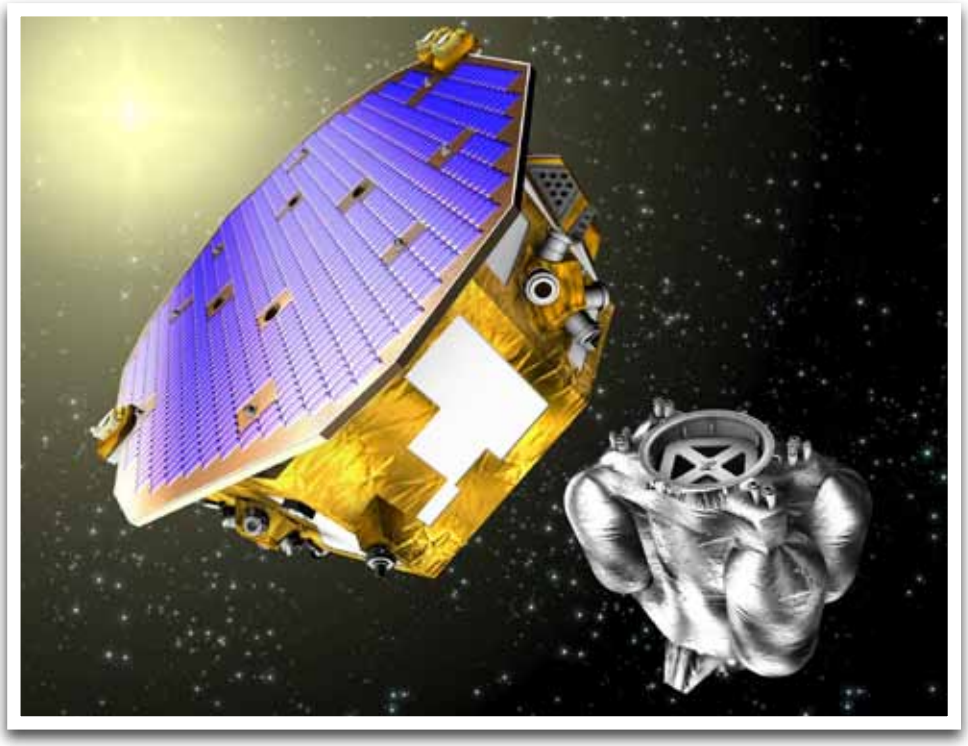
Since the Gaia's second massive data drop in April 2018, scientists have released over 30 new research papers in just two days following the announcement.

One especially intriguing paper describes the possibility that a powerful gravitational force sent ripples through our galaxy, like a stone into a pond, between 300 million and 900 million years ago that might have been due to a close approach from the Sagittarius Dwarf Galaxy orbiting the Milky Way around 70,000 light years away.

The LISA (Laser Interferometric Space Antenna) is a hugely ambitious gravitational wave venture planned for launch in 2034 at a cost of $ 2,4 billion. LISA was initially planned as an ESA Cornerstone mission, in collaboration with NASA for launch in 2015. This was to have been a triangular gravitational interferometer with 5 million km sides to be flown in an Earth trailing heliocentric orbit.

In 2013 ESA selected "*The Gravitational Universe*" as the theme for its Large-3 mission for launch in the 2030s. On 20 June 2017 LISA received its clearance goal and was approved as one of the main research missions of ESA for launch in 2034. LISA will comprise three spacecraft flying in triangular formation with sides of 2,5 million km. The spacecraft will fly in formation in an Earth trailing orbit 50 million km from Earth.

Each spacecraft will have two telescopes, two lasers and two test masses. The test masses are 46 mm 2 kg blocks of gold coated gold-platinum arranged in optical assemblies



The proposed LISA mission will detect gravitational waves in space using a trio of satellites that employ lasers to measure the changes in their relative distance caused by gravitational waves.

pointed at the other two spacecraft forming a Michelson-type interferometer. It must be remembered that at atomic level the concept of a smooth flat surface does not exist. The triangular formation will be tilted at 60 degrees to the ecliptic.

To eliminate non-gravitational forces such as light pressure and solar wind on the test masses, each spacecraft is constructed as a zero-drag satellite, and effectively floats around the masses, using capacitive sensing to determine their position relative to the spacecraft, and very precise thrusters to keep itself centred around them.

The time required for the laser beams to travel the length of the interferometer arms will be 8,3 seconds so it will be necessary for the lasers to accommodate the point-ahead angle of the incoming and outgoing beams. It will be necessary for LISA to measure relative displacements with a resolution of 20 picometres – less than the size of a helium atom. Over the length of the beam this is a strain sensitivity of less than 1 part in 10^{20}. LISA Pathfinder was a test mission launched in 2015 to test the technology necessary to put a test mass in almost perfect free fall conditions. This was a short arm (38 cm) interferometer placed at the L1 point of the Earth's orbit where it underwent payload commissioning.

It was possible to measure the distance between the two test masses on board to a precision of less than the diameter of an atom. The LISA Pathfinder was decommissioned in June 2017. Expectations were exceeded by a large margin. WN

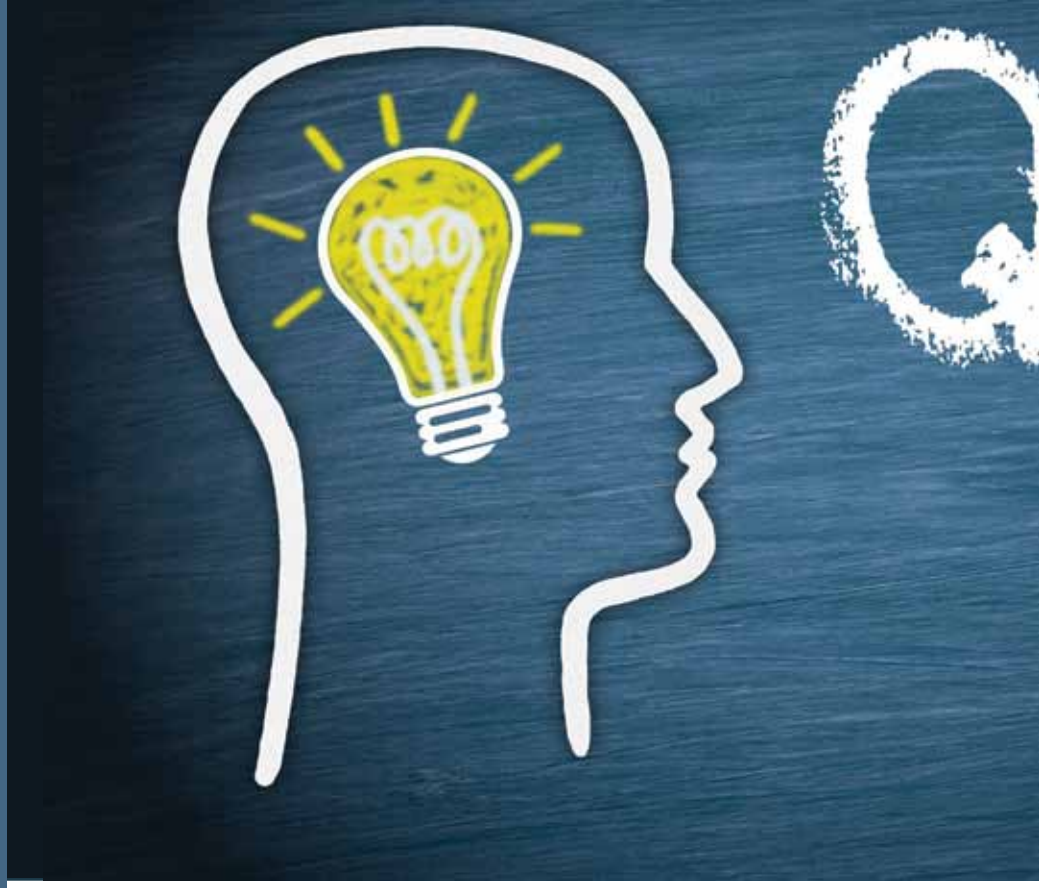
WATT? is a forum related specifically to the industrial and commercial electrical sector.

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

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

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

We look forward to hearing from you.
- Ed



QUESTION ONE

What preliminary inspections are required before an electric motor is started for the first time, or when an electric motor is started after it has been in storage for a prolonged period?

ANSWER ONE

The first step for the preliminary inspection is to ensure that the motor is clean and that all packing and cleaning materials have been removed. Thereafter the following procedures will assist in determining whether the motor is ready for commissioning:

- Make sure that the supply voltage and frequency correspond to those indicated on the rating plate.
- Determine if the end shield and bearing housing fastening bolts on the motor are firmly tightened.
- Make sure that the motor is correctly aligned according to the manufacturer's specifications.
- Ensure that the bearings are correctly lubricated as indicated on the motor rating plate.
- Inspect the rotor terminal connection on slip ring motors.
- Ensure that the thermal protector conductors, grounding terminal and the space heaters are connected.
- Measure the insulation resistance of the stator winding, and ensure that the measurements are within the manufacturer's specifications.
- Ensure that all objects, such as tools, measuring instruments and alignment devices, are removed from the area of the motor.
- Inspect the condition of the brush holders and ensure the brushes are making contact, if applicable.
- Confirm that all motor fixing bolts are tightened sufficiently.
- The motor must be started at no load before it is coupled in its respective application. Ensure the motor rotates freely without abnormal noise and confirm that the direction of rotation is correct. (To reverse the rotation, invert any of two terminal leads of the power supply).
- Ensure that the motor ventilation is in order by inspecting the direction of rotation.

QUESTION TWO

What is the purpose of maintenance on grease lubricated bearings for electric motors and what procedures are recommended for condition monitoring of the bearings?

ANSWER TWO

The purpose of maintenance is to lengthen the bearing life. Maintenance includes but is not limited to the overall status of the bearings, the cleaning and lubrication of the bearings and a detailed inspection of the bearings. Motor noise, vibration and bearing temperature are typical measurements that can be obtained during motor operation to ensure the longevity of the bearings.

Motor noise should be measured at regular intervals of between one to four months. A well-tuned ear is perfectly capable of identifying unusual noises, even with rudimentary tools such as a screwdriver. For a more reliable analysis of the bearings, sophisticated equipment is required.

Bearing temperature control also forms part of routine maintenance. The temperature rise of grease lubricated bearings should usually not exceed 60°C (T = 60°C; Tambient = 40°C; Tabsolute = T + Tambient) measured at the external bearing cap. It is, however, imperative to ensure that the temperatures are within limits specified by the bearing manufacturer.

Constant temperature control can be done using external thermometers or by embedded thermal elements. Motors are typically supplied with grease lubricated ball or roller bearings with alarm and tripping temperatures for the bearings set at 90°C and 110°C respectively.

Bearings should be lubricated as indicated on the motor rating plate to avoid metallic contact of moving parts, and also for protection against corrosion and wear. Lubricant properties deteriorate in the course of time and due to mechanical operation. Besides, all lubricants are subject to contamination under working conditions. For this reason, lubricants must be renewed or replaced from time to time. wn

Information provided by Zest WEG Group

July

Movers, shakers and history makers

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

1 JULY

1646 Gottfried Wilhelm von Leibniz was born in Leipzig. During his 70-year life, Leibniz made significant contributions to the field of mathematics as well as completing some early computer work in the form of a calculator. Leibniz is best known for developing the modern forms of differential and integral calculus.

2 JULY

1935 After 28 years of trying, the South African Cricket Team won their first test match at Lord's Cricket Grounds, London, against England.

3 JULY

1997 California's ergonomic standard came into effect. Its purpose is to dictate what employers must do to ensure that their workplaces prevent repetitive motion injuries like carpal tunnel syndrome. The new law reflects the severity of such injuries, largely due to increased computer use.

4 JULY

1054 Astronomers saw a supernova (a violently exploding star) that was visible in daylight for 23 days and at night for almost 2 years. It is believed the Crab Nebula in the constellation Taurus is the remnant of this supernova.

5 JULY

1937 Hormel Food Corporation introduced SPAM, canned pre-cooked meat. As it was difficult to get fresh meat to soldiers during World War II, SPAM became commonplace in a U.S. soldiers' diet. Today SPAM is sold in over 100 countries.

6 JULY

1920 A U.S. Navy seaplane departed from Virginia and headed out over the ocean. Using a new radio compass, the pilots were able to locate and fly directly to a Navy ship nearly 100 miles offshore. It was the first use of radio navigation by an aircraft.

7 JULY

1981 The first solar-powered aircraft, Solar Challenger, crossed the English Channel.

8 JULY

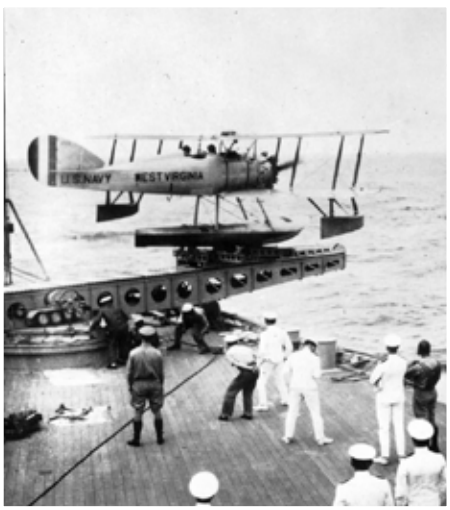
1933 The first rugby union test match between the Wallabies of Australia and the Springboks of South Africa was played at Newlands Stadium in Cape Town.

9 JULY

2002 The African Union was established in Addis Ababa, Ethiopia, replacing the Organisation of African Unity. The organization's first chairman was South African President, Thabo Mbeki.

10 JULY

1940 The Battle of Britain started with the first of a long series of bombing raids against Great Britain. It has been described as the first major military campaign fought entirely by air forces.



11 JULY

1979 Parts of Skylab, America's first space station, come crashing down on Australia and into the Indian Ocean five years after the last manned Skylab mission ended. No one was injured.

12 JULY

1960 The Etch A Sketch went on sale for the price of $2.99. It went on to sell 600,000 units that year and is one of the best-known toys of that era. In 1998, it was inducted into the National Toy Hall of Fame, New York.

13 JULY

2001 The Code Red worm was released onto the Internet. Targeting computers that ran Microsoft's Internet Information Services web server, Code Red had a significant effect on the Internet due to the speed and efficiency of its spread.

14 JULY

1867 Alfred Nobel demonstrated dynamite for the first time at the Merstham Quarry, Surrey in southern England.

15 JULY

1928 German engineer Arthur Scherbius invented the Enigma machine, which produced encrypted messages. This device turn a message into a jumble of code so that if the message got in the wrong hands, it could not be read.

16 JULY

1995 *"Fluid Concepts & Creative Analogies: Computer Models of the Fundamental Mechanisms of Thought"* was the first book Amazon sold. The company ran from a garage in Washington, USA. Three SPARC machines was all they had and a cool little mechanism that rang a bell every time a book was sold.

17 JULY

1975 Apollo 18 (the officially unnumbered Apollo spacecraft) and Soyuz 19 successfully docked in orbit and the astronauts and cosmonauts shook hands.

18 JULY

2017 It was announced that a shrinking glacier in Switzerland revealed two frozen bodies believed to be Marcelin and Francine Dumoulin who went missing in 1942, despite extensive searches. DNA results confirmed the find. They were parents of seven children, who had gone to feed their cattle in a meadow on August 15, 1942.

19 JULY

2000 Apple introduced the G4 "Cube" Power Macintosh. At that time, it was one of the smallest desktop computers ever produced. While not considered a commercial success, it gave an indication of what future Apple designs would be like.

20 JULY

1976 On the seventh anniversary of the Apollo 11 lunar landing, the Viking 1 lander, an unmanned U.S. planetary probe, becomes the first spacecraft to successfully land on the surface of Mars.

21 JULY

1999 The iBook laptop was introduced by Apple, the first mainstream computer designed and sold with built-in wireless networking.

22 JULY

1990 Greg LeMond, an American road racing cyclist, won his third Tour de France after leading the majority of the race. It was LeMond's second consecutive Tour de France victory.

23 JULY

2015 NASA scientists announced the discovery of Kepler-452b, the first near-Earth sized exoplanet (a

July

continues from page 63

planet outside of our solar system) discovered orbiting the habitable zone of a Sun-like star.

24 JULY

1998 The South Korean government opened the bidding for the Kia Motors Corporation, the country's third-largest car company, which had gone bankrupt during an economic crisis that gripped much of Asia. Hyundai managed to win the auction with the highest bid.

25 JULY

1959 SR.N1, an all-metal hovercraft, crossed the English Channel for the first time in 2 hours 3 minutes. It was 50 years to the day that Louis Blériot made the first crossing of the Dover Strait by aeroplane.

26 JULY

1963 Syncom 2, the world's first geosynchronous satellite (from Earth, the satellite seems to "hover" over the same spot), was launched. During the first year of Syncom 2's operation, NASA conducted voice, teletype, and facsimile tests, as well as 110 public demonstrations to show the capabilities of this satellite.

27 JULY

1949 The world's first jet-propelled airliner, the British De Havilland Comet, made its maiden test-flight in England. The jet engine would ultimately revolutionize the airline industry, shrinking air travel time in half by enabling planes to climb faster and fly higher.

28 JULY

1997 Dell Computer Corporation announced its entry into the workstation market with the Dell Workstation 400. The move to the more powerful desktop computers, most commonly used for engineering, followed Dell's entry into the network server industry.

29 JULY

2017 The Charles Kuonen Bridge in the Swiss Alps, was officially opened. It is the longest hanging pedestrian bridge in the world. The bridge spans 494 metres and runs 85 metres above the ground at its highest point. It has 8 tonnes of cables and has a system that prevents it from swinging. The bridge is part of Europaweg, a hiking path between the Swiss villages of Zermatt and Grächen.

30 JULY

2003 The last of 21,529,464 Volkswagen Beetles built since World War II rolled off the production line at Volkswagen's plant in Puebla, Mexico. One of a 3,000-unit final edition, the baby-blue vehicle was sent to a museum in Wolfsburg, Germany, where Volkswagen is headquartered.

31 JULY

1971 Astronaut David Scott used a Lunar Roving Vehicle (LRV), powered by batteries, and became the first man to drive a (electric) car on the surface of the moon. wn

= Earn CPD Credits

calendar

JULY | AUGUST | SEPTEMBER | OCTOBER 2018

JULY 2018

2 - 7	2018 IEEE International Congress on Internet of Things (ICIOT)	San Francisco, USA	www.conferences.ieee.org
3 - 4	Optical Fibre Technology and Networks (OFTN)	Johannesburg	roberto@saiee.org.za
4 - 7	8th Scientific Computing to Computational Engineering Conference	Glyfada, Greece	www.scce.gr
10 - 11	Smart Grid Systems	Johannesburg	roberto@saiee.org.za
17 - 18	Smart Procurement World Natal	Durban	www.smartprocurementworld.com
18 - 19	Substation Design And Construction	Johannesburg	roberto@saiee.org.za
17 - 19	PowerGen Africa & DistribuTech	Johannesburg	www.powergenafrica.com
21 - 23	2018 3rd Asia-Pacific Conference on Intelligent Robot Systems (ACIRS)	Singapore	www.acirs.org
24 - 26	2018 2nd International Conference on Biomedical Engineering (IBIOMED)	Bali, Indonesia	www.ibiomed.ugm.ac.id
26 - 27	LV, MV & HV Switchgear Operation, Safety, Maintenance	Johannesburg	roberto@saiee.org.za
26 - 27	Advanced MS Excel For Engineers	Johannesburg	roberto@saiee.org.za

AUGUST 2018

6 - 7	2018 Advances in Big Data, Computing & Data Communication Systems	Durban, RSA	www.icabcd.org
6 - 8	2018 IEEE Symposium on Safety, Security, and Rescue Robotics (SSRR)	Pennsylvania, USA	www.ssrr2018.org
7	SAIEE - Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
10 - 12	2nd Industrial Engineering & Technology Management Conf.	New York, USA	www.icietm.com
13 - 15	2018 IIndustrial and Commercial Use of Energy (ICUE) Conference	Cape Town, RSA	www.energyuse.org.za
15	Optical Fibres, Cables and Systems Fundamentals	Johannesburg	roberto@saiee.org.za
20 - 22	2018 Power Science & Engineering Conference	Vienna, Austria	www.icpse.org
23	Fundamentals of Long-Term Evolution (LTE) Mobile Communications	Johannesburg	roberto@saiee.org.za
27 - 30	2018 International Conference on Radar (RADAR)	Brisbane, Australia	www.radar2018.org
28	Managing Projects Effectively	Johannesburg	roberto@saiee.org.za
30	Arc Flash Workshop	Johannesburg	roberto@saiee.org.za

SEPTEMBER 2018

19	Incident Investigation & Management	Cape Town	khuvutli@saiee.org.za

OCTOBER 2018

9	Substation Design and Construction	Cape Town	khuvutli@saiee.org.za
26	Annual SAIEE Banquet	Midrand Conference Centre	geyerg@saiee.org.za

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E|mashegol@gmail.com

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T| 0448714925 **E**|jgfswanepoel@gmail.com

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T|083 256 7177 **E**|martinus.beumer@proconics.co.za

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