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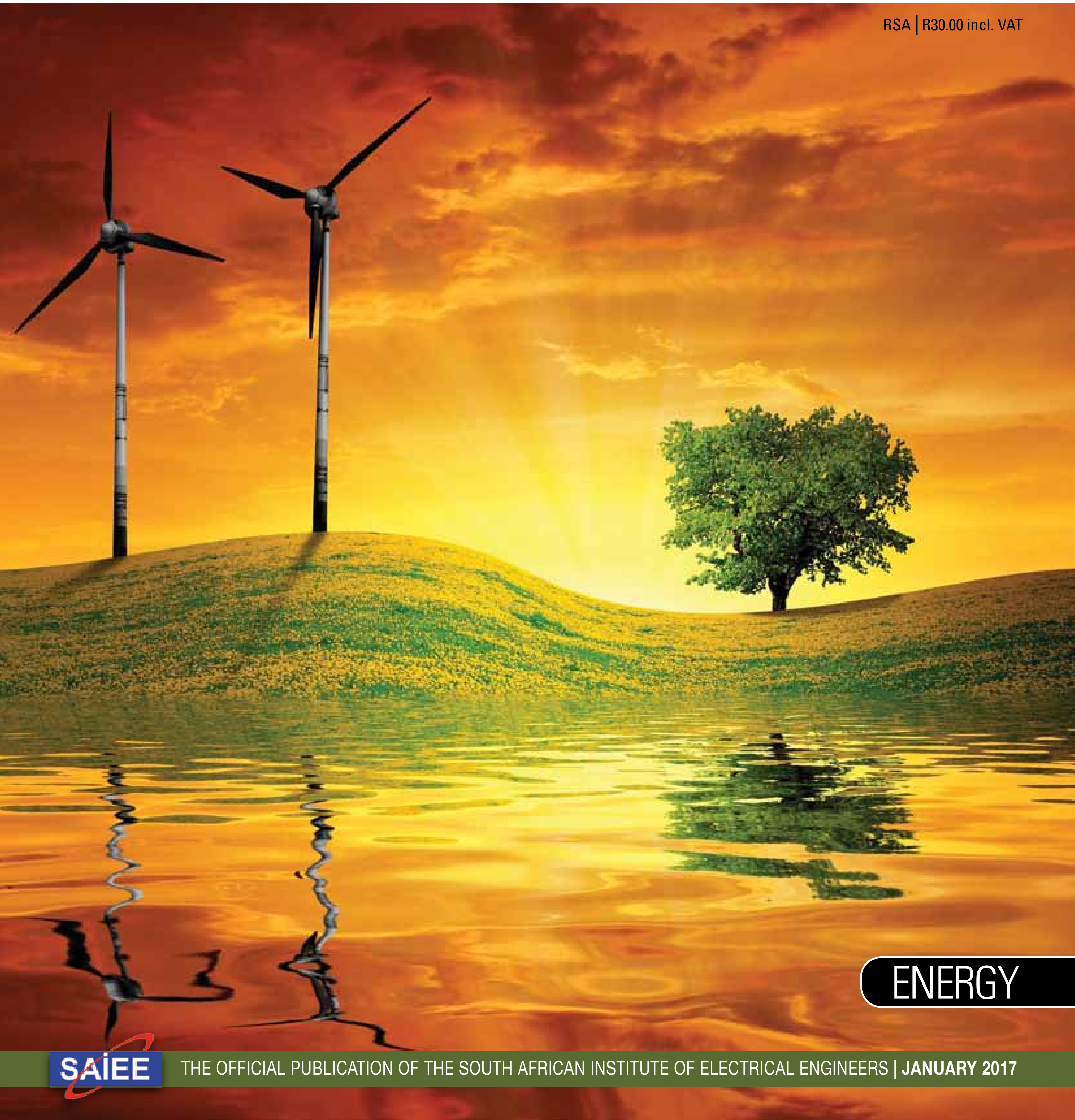

ENERGY

SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | **JANUARY 2017**

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REGULARS

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ISSN: 1991-0452

January is here! It is a slow start to get back into the swing of things. I trust you and yours enjoyed a fabulous festive season and are bright-eyed and bushy tailed for the New Year! Let's keep our heads high and face whatever this year might dish out! Bring it on!

This issue of **watt**now features Energy and we take a look at various aspect of energy. The first feature article takes a look at why South Africa's Energy Plan sparked strong emotions. Read more on page 20.

Page 24 gives an Energy insight into reducing energy cost and increased efficiency. L Hunt wrote an article on page 30, on the use and abuse of energy - the what to do and the what not to do!

I have had a huge influx of emails in the past month from members who replied to my request about the online vs print format of the **watt**now. Thank you very much. Once again I urge our members who have not responded yet - to please let me know your preference. As you might know, the production cost of any magazine, including **watt**now, is astronomical. The icing on the cake is that we cannot rely on the South African Post Office to deliver a decent service.

I, therefore as the Managing Editor, request you to send an email indicating if you would prefer to receive an online, downloadable version, or a printed copy of the **watt**now magazine.

Your input as a SAIEE Member is extremely valuable to me, and I require your feedback to assist me in establishing the correct way forward.

Please send an email to **wattnow@saiee.org.za** and include in the subject line YOUR SAIEE MEMBERSHIP NUMBER & **watt**now online/print – **whichever you prefer**. Members, who opt for their printed copy, will still receive their copy in the post. If I do not receive an email from you by 31 March 2017 you will automatically receive the online copy.

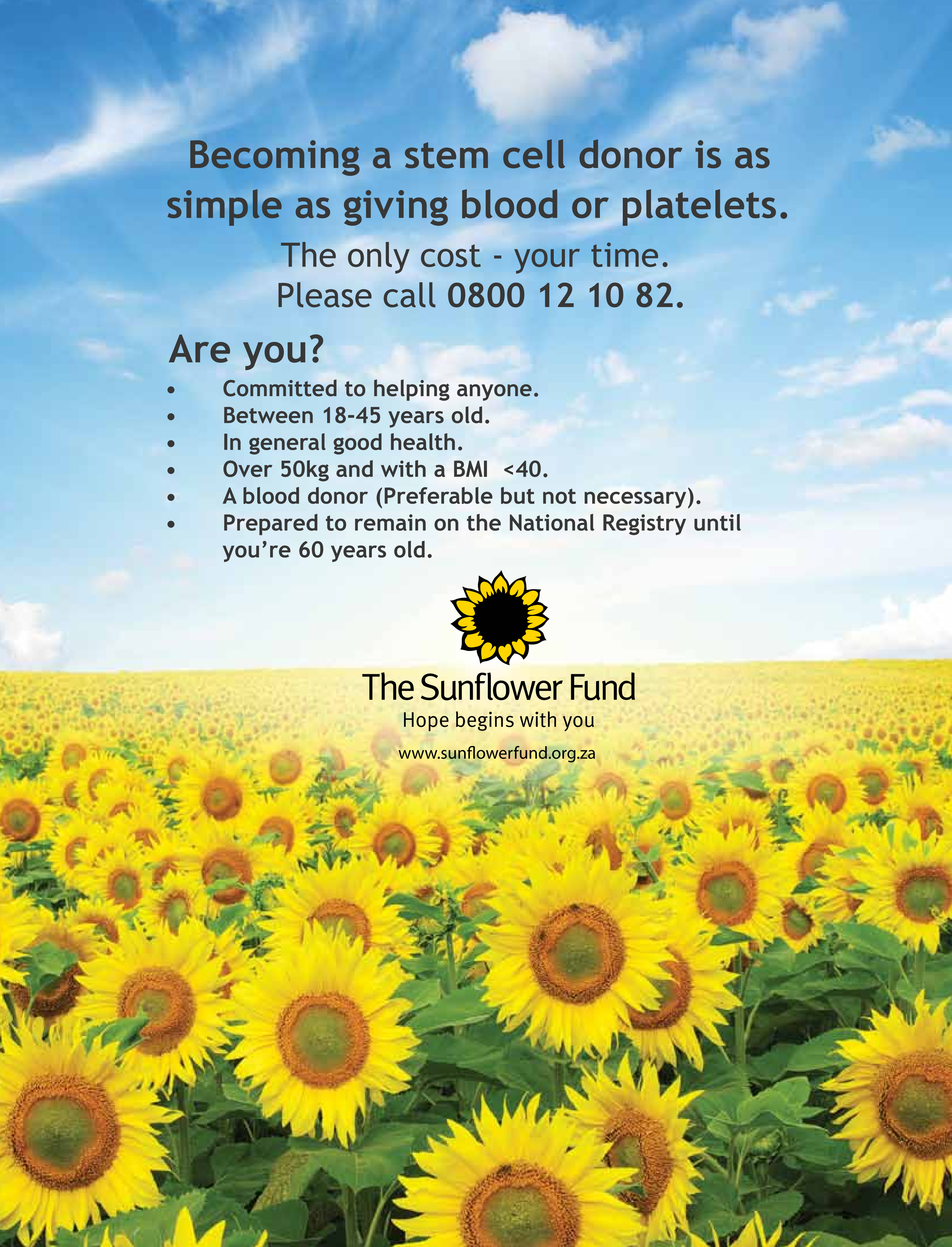
I wish all of you a wonderful and succesful 2017. May it be a blessed one.

Enjoy the read.

Minx

Earn CPD Credits

Visit www.saiee.org.za to answer the questions related to these articles to earn your CPD points.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TC MADIKANE
2016 SAIEE PRESIDENT

New Year is the time to explore new horizons and realise new dreams. I wish you all a prosperous 2017 with wonderful opportunities and have a fun filled festive season.

2016 was a busy year. It was my privilege to meet any of our members at all of our centres. This year's activities included the Presidential Address, the 65th Bernard Price Memorial lecture, Student Chapter functions to mention but a few. Through these we have come to understand the expectations of members of this glorious movement and learned society of Electrical Engineering Practitioners. The Council is working hard to ensure that our members are getting value for their money and that will be more visible this year.

On the 10th of November, I attended the Inauguration of South African Institution of Civil Engineering (SAICE) President, Mr Sundran Naicker at the Melrose Arch. The following day, I had to be back in Durban to witness a milestone in the education fraternity where SAIEE/ESKOM/MUT discussed the Memorandum of Understanding (MoU) pertaining to in-service training of MUT Electrical Engineering Students. Thank you to Eskom management for #ploughback and #makeithappen. There are a number of students who have completed their training, but have not been able to find placement for P1 or P2. They should benefit from this. On the same day, together with the CEO and some of the EXCO members we attended KZN SAIEE's Annual Awards and dinner event at the Durban Country Club. Congratulations to all the recipients of the awards for 2016.

The SAIEE Staff's Year-End Function took place at the Emperors Casino's Barnyard Theatre on 18th Of October. We were entertained by a band that reminded us of the 70s music. The Past Presidents' Forum luncheon took place on the 22nd of October. The Past Presidents agreed to award additional bursaries from the President Purse fund. Thank you to the Past Presidents for contributing positively to the issue of #FeesMustFall. The National Student Project Competition took place at the North West University, Potchefstroom Campus on the 24th of November. There were seven Universities that participated in 2016. The projects presented were of high standard. The Judges had a challenging task to award the best project for 2016. Thank you to all the Judges that availed themselves as Plough Back to the profession and well done to Cornelis Neethling for scooping the award.

The long awaited prestigious 65th Bernard Price Memorial Lecture that was supposed to take place at the Senate House, East Campus, Witwatersrand University, eventually took place on 1st of December at the Military Museum. It was well attended. Once again thank you to our Guest Speaker, Prof Tshilidzi Marwala, for an inspiring and great talk, "the Fourth Industrial Revolution: Artificial Intelligence and Society". The event is available on YouTube for those who missed it. 2016's last event was the inauguration of Institute of Professional Engineering Technologist (IPET) President, Mr Jones Moloisane. We congratulate Jones and look forward to working with him as SAIEE.

Thank you to SAIEE staff members who worked hard in 2016. I hope they will use this break to re-charge.

I look forward to 2017 ensuring that SAIEE is the preferred learned society for all Electrical Engineering Practitioners. I would also like to extend a word of appreciation to all our Council Members and Volunteers who handle Professional Registration of Candidates and University Accreditation on behalf of the Engineering Council of South Africa (ECSA). Your contribution to the engineering fraternity goes a long way, towards #ploughback and #makeithappen.

TC Madikane
Pr. Eng | FSAIEE | FSAAE

EUROLUX PROJECT SOLUTIONS

Enhance your commercial and industrial environments

Eurolux Project Solutions offers a variety of energy efficient lighting solutions. Recent projects include Caxton Publishing House, Namibia Breweries, Hyundai Showroom, the River Club, the renowned Hotel Verde: The greenest hotel in Africa; as well as the Agulhas Marine research vessel.

Eurolux offers a comprehensive lighting design and specification solution to its customers – all completed by a qualified lighting engineer.

- A project begins with the initial site inspection and customer briefings.
- A detailed lighting design, with full 3D simulation and energy efficiency report, to comply with SANS and OHS, is then presented to the client.
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National Student's Project Competition

The 2016 National Students Project Competition was hosted by the North West University, Potchefstroom on the 24th of November. Eight students participated for the coveted title, representing various tertiary establishments across South Africa.

The 2016 judges who volunteered their time for this competition are Stan Bridgens, TC Madikane, Wayne Fisher, Pascal Motsoasele and André Denobili.

The morning started with the opening of the competition by the Director of the School of Electrical, Electronic and Computer Engineering, Prof. George van Schoor, followed by a warm welcome and greeting by SAIEE President, T.C. Madikane.

As usual the students did not disappoint! Each student presented an impressive gadget. They were so diverse that it was a difficult task to select the winners.

The winner of the 2016 National Students Competition is Brinco Neethling of North West University. His model and presentation of the Automatic Cupcake Piper had ticked all the boxes with the judges, and impressed all attendees.

The SAIEE awarded two discretionary prizes for top class work. These were awarded to Bernard Bussy from University of Kwa-Zulu Natal, and Bradley Stocks from University of Cape Town.

The 2016 National Student Competition winner, Brinco Neetling from North West University (NWU) with Leenta Grobler from NWU.

The winning project, an automatic Cupcake Piper.

All the participant in the 2016 National Student's Project competition, from left: Giles Maybery (Stellenbosch), Brinco Neethling (NWU), Bernard Bussy (UKZN), Andrew Smith (UJ), TC Madikane, Bradley Stocks (UCT), Philip Motloung (TUT), Devin Taylor (Wits) and Ronen Freeman (Wits).

2016 Bernard Price Memorial Lecture

December saw the 65th Bernard Price Memorial Lecture taking place at the Military Museum in Johannesburg. Prof Tshilidzi Marwala did the honours, in sharing with our members *"The Fourth Industrial Revolution: Artificial Intelligence and the Society"*. The First Industrial Revolution, occurred in Britain in the 17th and 18th century. It was an epoch in economic development, which ushered in the use of steam powered machines in production. The Second Industrial Revolution gave us electricity, automobiles and airplanes. The Third Industrial Revolution gave us the digital age.

The Fourth Industrial Revolution is characterized by making systems, as well as machines, intelligent and connected. The underlying technology of this is Artificial Intelligence (AI). Prof Marwala had our members hanging on every word he said.

From left: Prof Marwala with his family and SAIEE President, TC Madikane.

SAIEE President, TC Madikane with ***watt****now Managing Editor, Minx Avrabos.*

From left: Ian McKehnie and Prof Bea Lacquet.

From left: Humphrey Matlala and David Nzikazi.

From left: Dries Wolmarans, Prof Zeblon Vilakazi and Prof Ian Jandrell.

From left: Jack Rowan and Thavi Govender.

From left: Prof Pat Naidoo, Andries Tshabalala and TC Madikane.

From left: Emmanuel Mukona and Gerda Geyer.

From left: Igor Djurdjovic, Thavi Govender and Gavin Strelec.

From left: Prince Moyo and Collin Matjaba.

WATTSUP

DEHN Africa honours partners in third annual awards ceremony

DEHN Africa, a lightning and surge protection solutions provider, recently acknowledged its local distribution partners, hosting its third annual African partner awards ceremony in Johannesburg.

The event started with a look into the company's upward trajectory over the past few years, covered its current changes and also gave a glimpse of its future plans for the African market. These plans include the further development of its DEHNacademy seminars, training and workshops. DEHN Africa managing director, Alexis Barwise once again highlighted the importance of a strong team and partners, and talked about exciting international changes as DEHN evolves towards becoming a process orientated organisation that is growth promoting and self learning. Another critical development is the ability to customise unique solutions in different geographical areas, meaning that the region specific needs of African clients can be catered for.

He also outlined the local organisation's goal for 2020, which is to position DEHN as one of the top three lightning protection and energy quality solutions companies in the most important industrial and growth regions.

Partners honoured at the event included:

- ARB Electrical Wholesalers, Most Innovative Marketing;
- ICE (Industrial Control & Engineering Namibia), Most Up and Coming Partner;
- Advanced Lightning Protection (ALP), Fastest Growing Partner; and
- Universal Lightning Protection Services (ULPS), Best Performance Overall.

From left: Kirk Risch, DEHN Africa and Seath Scowby, Universal Lightning Protection Services; winner of Best Performance Overall Award.

Long standing DEHN partner, Surgetek received a special acknowledgement - a framed contract from 1984 with a signature of the founder and former CEO of Surgetek, Hans Slagter - recognising the thirty-year partnership between the two companies and their lengthy commitment to the market.

SAIEE Long Service Awards

Herbert Hlanze, Androzette Muller and Sue Moseley recently received their Long Service Awards at the November Council Meeting. The SAIEE Awarded Long Service awards to: Herbert Hlanze (20 years), Gerda Geyer (18 years), Stan Bridgens (10 years), Sue Moseley (8 years), and Androzette Muller (6 years).

TC Madikane with Androzette Muller.

TC Madikane with Sue Moseley.

TC Madikane with Herbert Hlanze.

Energy Efficient Solution From Zest WEG Group For Yanfolila

Access to an OEM that can cover the full electrical scope of supply for mill applications is a major advantage and this is exactly what secured the Zest WEG Group the contract for the supply of an energy efficient solution to drive the mill at Yanfolila Gold Project in Mali.

Yanfolila Gold Project is being developed by Hummingbird Resources as a low cost, high grade open pit mining operation. Its first gold production is targeted for 2017.

Following close collaboration with the mill Original Equipment Manufacturer (OEM), Zest WEG Group provided an optimum solution which will meet the performance parameters of the milling circuit while ensuring cost efficient operation.

David Claassen, executive at Zest WEG Group, says that this is a good example of where the group is able to leverage not only its extensive expertise in electrical solutions for mill circuits, but its access to a comprehensive range of quality products.

The electrical solution for Yanfolila Gold Mine includes a 2 000 kW, 6 pole, 6,6 kV squirrel cage WEG electric motor, a medium voltage WEG Variable Speed Drive and a dry type phase shift transformer. The VSD and transformer will be housed in a custom engineered and manufactured sub-station. The sub-station will be manufactured and fully tested at Zest WEG Group's sub-station and panel facility in Johannesburg.

The electrical solution is scheduled for delivery to site in the first quarter of 2017 and Zest WEG Group will be responsible for all interfacing between the VSD and upstream MV switchgear, output isolation and complete control and protection system including frozen charge protection.

David Claassen,
Executive at Zest WEG Group.

NEPAD and the Implementation of Africa's Renewable Energy Projects Initiative

NEPAD, being the implementing arm of the African Union (AU), is embarking upon an exercise that accelerates the development and implementation of Africa's High Priority Renewable Energy Projects.

This is the NEPAD Agency's contribution to the implementation of the Africa Renewable Energy Initiative that was endorsed by the AU Summit in June 2016 and also to the SE4ALL Initiative. The exercise involves the provision of a platform where project owners at national level directly present their chosen projects to developers and financiers and strike business deals for either the development of projects to bankability, or financially close a project if it has reached bankability.

The first batch of projects will be from the countries that have completed or are in the process of completing the Action Agenda and Investment Prospectus of the Sustainable Energy for All Initiative (SE4ALL).

The NEPAD Agency is cooperating with The Africa Energy Indaba conference to host focused sessions where country project owners will present their selected projects to potential investors, developers and other interested stakeholders, who would consider funding these projects for further development or implementation.

NEPAD Senior Energy Advisor, Professor Mosad Elmissiry, commented, *"This will be the first time that country governments will be showcasing their High Priority Renewable Energy Projects to the open market and looking to attract private sector participation and investment. Our role is to faciliate and aid this matchmaking to ensure these projects are developed. We believe this is what the private sector has been looking for - opportunities to view new renewable energy project opportunities by the project owners."*

The Africa Energy Indaba in Johannesburg from the 21-22nd February 2017, will host the SE4ALL countries that will be showcasing their High Priority Renewable Energy Project Opportunities, identified at country level as the "High Priority Projects" to provide energy to the respective country.

The actual project owners (country government representatives) will be providing the full Investor Prospectus at the Africa Energy Indaba and showcasing the High Priority Project Opportunities to the private sector to consider for investment.

WATTSUP

AVeS wins big at 2016 ESET Partner Awards

Professional IT services consultancy AVeS Cyber Security won big at the 2016 ESET Partner Awards. Of the 14 categories, AVeS clinched six, including National Highest Revenue Winner 2016 and Gauteng Highest Revenue Winner 2016. Seen here at the gala awards ceremony held at The Venue in Melrose Arch, Johannesburg, in November 2016 were: Charl Ueckermann, Diane Pieterse, Clint Carrick, Ria Mey, and Troy Carrick. The ESET Partner Awards are based solely on revenue. AVeS has been a prized ESET Partner since becoming part of its reseller network in 2009, and has since become one of its top resellers.

Ibhubesi Gas Project to supply South Africa with much-needed cleaner fuel

The Ibhubesi Gas Project (IGP) is a mature natural gas field development with eleven wells drilled thus far consisting of seven gas discoveries, which is an encouragingly high success rate. Having over half a trillion cubic feet (Tcf) of proven gas reserves at a 2P level and situated 80km off of the Northern Cape coast, the current IGP gas reserves could potentially provide electricity to a city of 1 million people for about ten years, making it a significant source of clean energy in the country. With added investment, up to 8 Tcf or 16 times the current proven reserves, could be added to the domestic energy mix.

In addition to the direct and indirect jobs that could potentially be created, the investment in the development of the IGP, which could top over R20-billion, would be a true upstream and downstream industry creation catalyst throughout its lifespan.

Remote, simultaneous, recordable wireless test tool system

Fluke, represented locally by The Comtest Group, has on offer Fluke CNX, a customisable, troubleshooting tool-set of wireless test tools that work together, recording live measurements remotely and simultaneously on a single screen. CNX Modules measure AC voltage, temperature and AC current with a standard clamp or flex clamp. Possible applications include:

- Detection of power interruptions
- Single phase measurement
- Determining current imbalance
- Measurement of incoming current

A wireless multimeter displays readings from up to three wireless modules, plus the meter measurement at the same time, on the same screen, from as far as 20 meters away. To get a holistic overview of the situation, readings from 10 tools measurements can be reviewed simultaneously on PC View. Users are able to mix and match the wireless-enabled modules to suit their unique measurement needs.

Fluke CNX meets Category 1000 V CAT III and Category IV 600 V safety standards.
For further information on Fluke's CNX wireless test tool system, of information about seminars, demos or to locate the nearest dealer, contact Comtest on 010 595 1821 or visit www.comtest.co.za

One school at a time: protecting children against lightning

Ugandan summer thunderstorms are practically a daily occurrence. The most dangerous by-product of these frequent storms is the approximately 70 lightning strikes per kilometre experienced within the country each year. Between 2012 and 2014, tragically more than 365 school children were killed due to lightning strikes.

In light of this, African Centres for Lightning and Electromagnetics Network (ACLENet.org), a Pan-African Network of Centres dedicated to reducing lightning related deaths, injuries and property damage, put in place a project called "Lightning Kills! Save a Life Africa" aimed at providing lightning protection equipment (including lightning rods, down conductors and grounding) to help safeguard African schools from strikes.

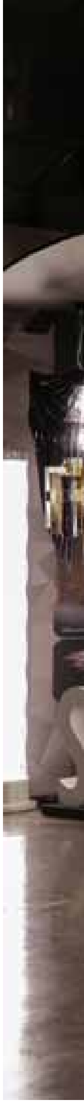
The organisation has teamed up with experts within the field, such as lighting protection company DEHN + SÖHNE.

DEHN + SÖHNE subsidiary, DEHN Africa initially conducted a risk assessment, followed by the customised design plan of a lightning protection system (LPS) for a school based in Runyanya, Uganda. The school, which has a total of 700 pupils, is the first in the region to have rolled out a comprehensive LPS.

Within three days, DEHN Africa installed the external lightning protection system - including earthing systems, air-termination rods and down conductors - on each building within the school premises, including the chapel.

Kirk Risch, sales and marketing director at DEHN Africa, says: *"This is the first of four similar school projects to be rolled out by DEHN Africa within the next few weeks. We have already sponsored the shipping of the required products and have trained our partner in Uganda, UltraTec World. UltraTec World assisted with the installation at Runyaya, and will complete the LPS installations at the remaining three schools.*

"It is the serious intention of both DEHN + SÖHNE and DEHN Africa to prevent similar tragedies to the one that occurred in Western Uganda in 2011, where a number of children were seriously injured and even lost their lives during a thunderstorm. These projects present an ideal opportunity for us to give back to the communities in which we operate, helping to create a safer environment."



An innovative new showroom concept

Eurolux is pleased to announce the launch of Euro Nouveau, a bespoke showroom concept that sees the designs of some of the foremost European lighting manufacturers exhibited in a luxurious new space at the Eurolux Head Office in Cape Town.

Euro Nouveau showcases the work of 12 to 14 hand-selected lighting designers, ranging from classics by Fontana Arte to the quirky pieces of modern Italian brand Slamp. The showroom's custom design creates a stage for each brand's work, showing off its unique functionality and style, while seamlessly complementing the other pieces in the space.

Stepping into Euro Nouveau is not unlike browsing the fantastical collections at some of Europe's foremost lighting shows, ultimately demonstrating Eurolux's position as an industry trendsetter who understands the needs of the most discerning buyers.

From elegant styles of the 1930s and 40s to ultra-modern architectural designs, Euro Nouveau presents a carefully curated selection that ranges from the Bohemian Crystal Chandeliers of Iris Cristal to the natural inspired designs of Manooi and the minimalist work of Inarchi, working collectively to form a space that is as sophisticated as it is innovative.

The simplicity of the Euro Nouveau concept adds to its exclusivity, with the space created such that each light can really shine! More than a showroom, Euro Nouveau is an exhibition hall, carefully curated and meticulously designed, for showcasing some of the finest lights in the world.

The Euro Nouveau collection caters to every taste and style, from sophisticated old-world inspired pieces in crystal and glass, to modern architectural styles in marble, chrome and steel. The diversity is not limited to the styles and materials, but also embodied in the colours of the pieces. Whether it's a toned down, natural palette you're after, or a striking pop of colour in a statement piece, Euro Nouveau has considered nearly every aesthetic.

It was important for Eurolux to have a South African brand represented in the new space too. It found a strategic creative partner in Carrol Boyes, the renowned local designer whose high-end home and lifestyle designs have been coveted by discerning buyers across the world for more than 25 years.

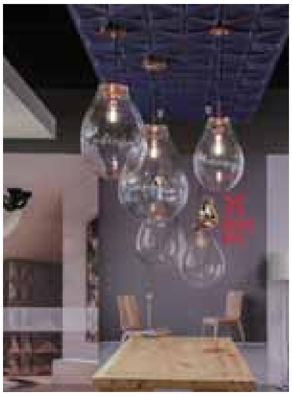
For Euro Nouveau, Carrol and her team have turned some of her most iconic designs into an exquisite range of floor, table, wall sconces and pendant lights. The pieces are simultaneously distinctly African and quintessentially Carrol Boyes.

Eurolux has taken great care in selecting distribution partners for the Euro Nouveau products across South Africa, as well as in Namibia, Botswana and Zimbabwe. These are typically lighting and decor traders that serve the niche categories to which the Euro Nouveau pieces appeal.

To enhance the purchasing experience for the client, each Euro Nouveau distribution partner will have its own unique showroom with bespoke pieces from the new range.

Euro Nouveau features lighting by the following European manufacturers:

Fontana Arte (Milan, Italy), Slamp (Rome, Italy), Iris Cristal (Spain), Manooi (Budapest, Hungary), Inarchi (Budapest, Hungary), Ivela (Milan, Italy), Lombardo (Villongo, Italy), Panzeri (Biassono, Italy), Karboxx (Basalghelle di Mansuè ,Italy), Serien (Frankfurt, Germany), Bomma (Czech Republic). wn



SAIEE Members visit Powertech Transformers

Powertech Transformers (PTT) is a subsidiary of Powertech, a wholly owned subsidiary of the ALTRON group. PTT operates from the original ASEA (Allmanna Svenska Elektriska Aktiebolaget) site, that was first commissioned in 1942. In November 2016, fourteen members of the SAIEE Power Section visited PTT's large factory in Pretoria West.

BY | DEREK WOODBURN **|** FSAIEE **|** TECHNICAL EDITOR: **watt**now

The team was welcomed with tea/coffee and muffins. An obligatory safety talk was given, as well as the applicable PPE required safety precautions for the factory tour.

PTT has an SABS Accredited Laboratory. The lab carries out oil analysis on all samples of their insulating oil, which is critical in the monitoring of ageing transformers. New oil is tested for water contamination. It is passed if it falls in the margin of less than 10 ppm (7.1 is normal). Water contamination can reach 225 ppm in older transformers. Only ESKOM and Powertech Transformers have such laboratories in Southern Africa. The SABS accreditation of Laboratories is granted per industry specific, as well as discipline type, such as oil testing and electrical calibration. This means that their "Accreditation Status" grows with their need.

A caged impulse generator, within the laboratory allows for HV tests to be carried out on individual components. The laboratory has the capacity to test up to 100 kV, and resistances of up to 1 TΩ.

The lab also has instrument calibration facilities. This is necessary to ensure that all factory floor measurements (that use tapes, torque wrenches, and verniers, etc.) are always accurate.

We were also able to see how the radii on the corners of samples of rectangular conductors were checked.

The PTT's Group Technology R&D section comprises three sections: mechanical design, electrical design, and the software development. On display in the section entrance, is a detailed, 3D printed model of a transformer (approximately 9 cm x 12 cm x 6 cm), designed from their in-house transformer design software. The design of this was proving the practicality of designs. PTT's R&D section using Finite Element Methodology (FEM) in their design work. These advanced processes assist in speeding up the design work for new products.

PTT has a partnership with various South African universities, where graduate students perform advanced research work.

NEWS

Before entering the main factory building, we saw the huge banks of freshly galvanised radiator panels, waiting to be despatched. These will be mounted on the large transformer tanks in situ.

The first main assembly area of the factory, is for conductors and their insulation (Powertech Insulation (PTI)). Extensive use is made of precision manufacturing techniques for the high density pressboard spacers. These are used in the manufacturing of large power transformers.

PTT makes use of high purity of copper and aluminium conductors, which are critical in achieving the high conductivity essential for the manufacture of large power transformers (LPT's).

In the conductor insulating section, we were shown how they check that no snags or sharp edges exist on the conductors. These conductors could cause damage to the thin layers of paper insulation.

The helical, or disc winding types, are wound on mandrels, horizontally in some cases, and vertically in others. The windings were either of the circular concentric type with either strip rectangular conductors, or continuously transposed conductors (CTC). The effects of high short circuit forces on the windings are taken into account both in design and manufacturing. Where fast transient voltage pulses are possible, the effects of oscillating forces are carefully evaluated.

A large display in the factory showed the current temperature and relative humidity. Great care is taken in how the stacking of the mitred core laminations are assembled. The laminations are carefully split from supplier rolls, and stacked, with no burrs to introduce eddy currents. The "fairly circular", stepped-lapped design improves the flux distribution, as well as minimising electrical losses and sound levels. The optimum design simultaneously provides cost efficiency, and control of temperature rise. The lamination core stacks are bound together with fibre-glass tape (pit bands).

It normally takes between 2 to 9 months to complete manufacturing and assembly of components for 5 MVA to +/-800 MVA transformers. The larger units can take up to nine months to complete.

An interesting fact is that there is a high scrap recovery rate (up to 60%) of copper, when customers return damage coils from sites.

Large transformers with tap changers in service, have a wide range of maintenance needs, such as contact replacement. This replacement depends on the operating duty cycles, which can be very high (electric furnace transformers) through to relatively low (remote distribution units).

The wide variety of tank designs under construction on the factory floor was impressive.

High noise levels are evident in the tank manufacturing section of the factory, especially as per the boiler making process. After fabrication the completed tank interiors are grit blasted, cleaned and painted. For the control of impurities and contaminations, the factory has various "clean" areas, requiring the wearing of plastic shoe covers.

There are enormous vacuum drying ovens (autoclaves), which ensures relatively low residual moisture in the insulation paper, is maintained until the transformer is impregnated with oil.

We were able to observe the testing of a completed transformer by an enormous Van der Graaf Generator. The test section of the factory has their own generator, for conducting the testing, so as not to disturb the Pretoria supply grid.

Transport to site of the final tested and passed transformers, (up to 800 MVA) can take several days. The low-bed trailers are only permitted to travel during daylight hours, and often require the Provincial Traffic Police to accompany them. In many cases, the stripped-down units exceed the maximum height to safely pass under freeway bridges. The units often have to travel to site via remote roads, where overhead power, and telephone lines may have to be moved, or temporarily shut down, to allow the transformer to pass through.

After a fascinating tour, the SAIEE visitors. The SAIEE group expressed their appreciation of the effort of time, planning and execution, that went into the site visit. It was a memorable, educational and enjoyable experience. wn

SA's groundbreaking solar charging system for electric vehicles

After a year of development, a smart grid pilot project for the energy-efficient charging of electric vehicles (EVs) through battery storage and energy management across a network of charging stations, has proved successful.

BY | HEATHER DUGMORE

Innovated by the uYilo e-Mobility Technology Innovation Programme – a national programme hosted by Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth – the project paves the way for a new era of green transport and smart cities.

Project leader and Deputy Director of the uYilo Programme, Hiten Parmar, is extremely pleased with the breakthrough: *"Charging EVs with optimised management of renewable energy is a groundbreaking achievement for South Africa and globally. We are not aware of anyone else who has achieved this kind of outcome incorporating demand management and load leveling."*

The uYilo Programme, situated within NMMU's innovation hub eNtsa, spans a number of faculties and departments at NMMU, including engineering, information technology and chemistry. With the software the uYilo team has developed, the green future of energy-efficient charging of EVs has become a reality.

Further technology advancements will also include opportunities to be able to transfer power from the EV into the grid or to power people's homes through a bi-directional charger. The 100% electric Nissan Leaf available in South Africa currently supports this feature of vehicle-to-grid functionality.

What this all means is that instead of the energy utility having to increase infrastructure for EVs, this system considerably reduces the load on the national grid.

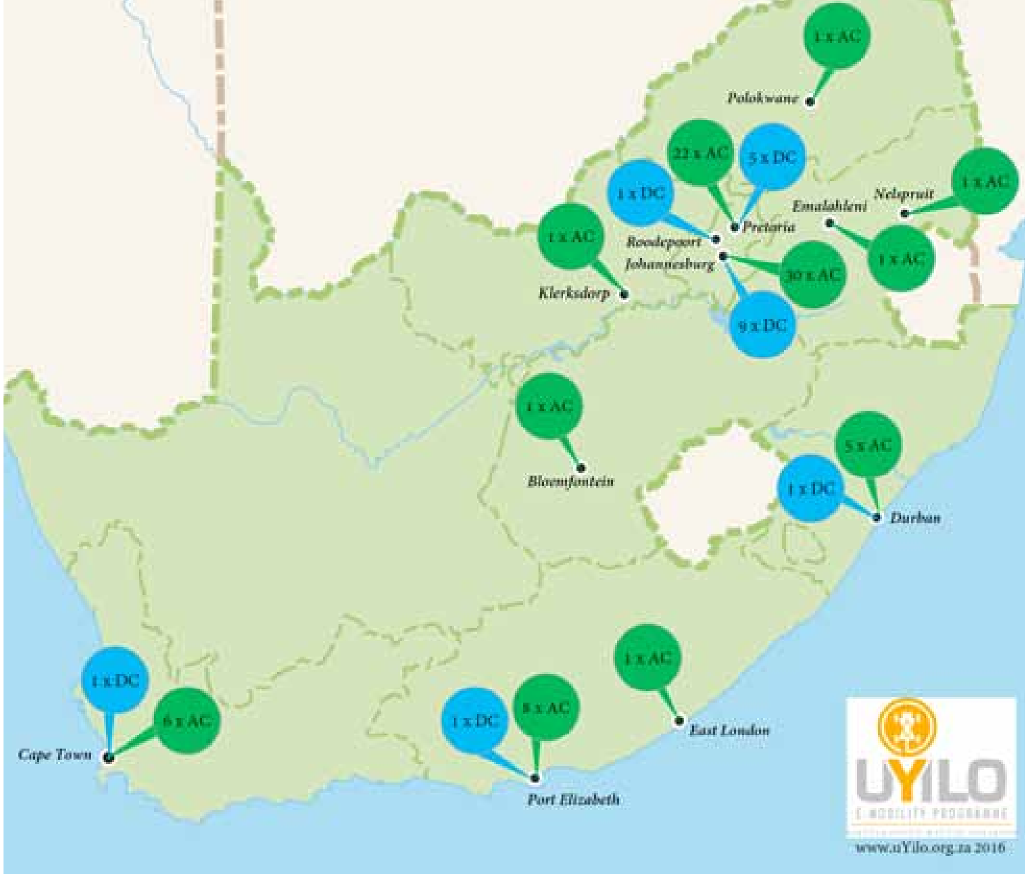
"Petrol and diesel vehicles are the biggest carbon emitters in the transport sector and the major thrust globally is to use renewable energy as far as possible to ensure that EVs are 100% green; powered by renewable energy sources and not fossil fuel generated, CO_2 emitting, sources of electricity," says Parmar.

"Within the next five years we are likely to see strict policies coming into effect around energy efficiency and green transport in South Africa. It's already happening globally. Japan already has more electric vehicle (EV) charging stations than fuel stations."

According to a recent study by Japanese vehicle manufacturer Nissan, there are now more than 40 000 charging ports across Japan compared to fewer than 35 000 fuel stations.

NEWS

Hiten Parmar
Deputy Director, uYilo Programme



Electric Vehicle Charing Stations in South Africa

"In the UK, EV charging stations will exceed gas stations by 2020, and the Netherlands is planning to ban the sale of petrol and diesel engines from 2025," Parmar adds.

A recent study published by uYilo cited that South Africa currently has 98 EV 'public' charging stations across the country, including 77 AC slow chargers, which take 3 – 8 hours to charge a battery, and 18 DC fast chargers, which take about 20 minutes.

Most of the charging stations are located at the Nissan and BMW dealerships nationally, but there are also some at Melrose Arch in Johannesburg and the V&A Waterfront in Cape Town.

A locally manufactured public AC charging system costs approximately R30 000 per charger installed, while DC charging systems are currently imported and cost approximately R400 000 per charger installed.

"Through our pilot project we've demonstrated that energy efficiency applied to solar-powered EV stations can be developed at scale because we have solved energy storage through re-using the lithium-ion battery pack from an EV for stationary storage. The energy management system prioritises each charging event, based on renewable and stored energy available, and incorporates a Time-of-Use feature to manage peak and off-peak charging. This way, EVs can be sustainably charged 24/7."

NMMU's uYilo Programme is accredited by the South African National Accreditation Society (SANAS) for lead-acid battery testing and will imminently expand on this to become the only facility in South Africa to provide certified lithium-ion battery testing.

Recharging an EV in South Africa currently costs approximately R30 – R40 for 130 – 150kms travelled. The two 100% electric EVs currently on the South African market are the Nissan Leaf and the BMW i3, both of which can drive for up to 200kms. The BMW i3 REX can drive for approximately 300kms; 130 of which are on its 9-litre, range extender, petrol engine.

Alan Boyd of the BMW Group in South Africa says that since the March 2015 launch of their fully electric vehicles they have sold 142 in South Africa and 60 000 worldwide.

Boyd says they expect to sell more if the economy improves and when the number of EV charging stations increases, and are installed for easy access at companies, business estates, shopping centres and apartment complexes. Many developers are already including EV charging facilities in their new buildings.

To date, the South African rollout of EV charging infrastructure has been primarily driven by the OEMs and private sector. In 2015, BMW SA and Nissan SA signed a MoU stipulating their collaborative efforts in the national implementation of EV charging infrastructure.

"We are ready to join hands with suitable partners to exponentially expand and revolutionise the current e-Mobility landscape in SA and internationally," says Parmar. wn

The much awaited updated South African Integrated Resource Plan (IRP) for electricity has been released for comment.

FEATURE

South Africa's new energy plan has sparked strong emotions. Here's why...

BY I HARTMUT WINKLER
PROFESSOR OF PHYSICS I UNIVERSITY OF JOHANNESBURG

The document makes far-reaching proposals about the target energy generation mix leading all the way to 2050. In particular, the plan pronounces on the future scale and role of nuclear energy and renewable energy technologies. The appropriateness of these has been debated a great deal in the country in the past few years.

If adopted in its current form, it will lead to a 15-year delay in the construction of new nuclear power plants. It will also result in a greater reliance on gas, solar and especially wind power than anticipated five years ago in the previous plan 2010-2030.

The proposed plan has already been the subject of intensive scrutiny and debate, with those for and against lining up to make their points. The state utility Eskom is unhappy about the suggested delay in building a much bigger nuclear capability, and has even threatened to ignore key recommendations. For their part, advocates of renewable energy argue that the plan underestimates how much less expensive these technologies will be in the next 20 to 30 years.

THE PREVIOUS ROAD-MAP

An earlier version of the integrated resources plan released in 2011 envisaged that between 2010 and 2030 South Africa's electricity demand would grow from 255 TWh (tera-watt-hours – a unit of energy) to 436 TWh. This was to be achieved through the completion of two very large coal power plants, Medupi and Kusile, which would supply the bulk of the shortfall. Other contributors would be nuclear, for which new plants would need to be built, and the establishment of a new renewable energy generation network of wind power and solar power.

BUT A GREAT DEAL HAS CHANGED SINCE THEN

Firstly, the growth in energy demand has proved to be lower than projected. Secondly, the cost of renewable technologies has dropped faster than expected. In particular, the price of solar photovoltaic electricity allocated under the country's renewable energy procurement programme fell by 75% between 2012 and 2015.

These developments were captured in an updated version of the 2011 plan that was prepared in 2013. It recommended that, in view of these changing conditions, there was no longer a need to kick-start

SA Energy Plan

continues from page 21

a nuclear build programme immediately. It also recommended that a decision on whether or not to embark on an expensive expansion of the nuclear reactor fleet could be delayed for several years.

But this updated version of the plan was never promulgated. This left the door open for a fiercely pro-nuclear lobby which is in favour of a highly lucrative nuclear expansion programme. This issue has developed into a political hot potato. The central argument is that the push for nuclear goes against economic common sense and that it's being pursued for the benefit of politically connected individuals.

The nuclear build issue has come to feature prominently as one of the important drivers of what is referred to as "state capture" of some of the country's large institutions.

THE LATEST VERSION

The draft update of the IRP advocates the following most likely scenario, referred to as the "base case".

Electricity demand between 310 and 355 TWh in 2030 (about 100 TWh lower than envisaged in the 2010-2030 plan) with demand rising to between 390 and 530 TWh in 2050. This is based on projection models developed at the Council for Scientific and Industrial Research.

The construction of 37.4 GW (1 000 GigaWatts equal 1 TeraWatt) of wind capacity and 17.6 GW of solar photovoltaic capacity between 2020 and 2050.

The gradual decommissioning of most existing coal power stations by 2050 in line with international carbon emission agreements.

A substantial increase (35.3 GW) in electricity generation from gas. Due to the high cost of gas it is generally used only as a back up. It would in any case contribute only about 7% of total energy generation.

The construction of just over 20 GW of nuclear power. But this would only gradually come on line between 2037 and 2050. Given that construction of the plants would take ten years, the decision to go ahead with the nuclear build could still be delayed for another decade.

INITIAL REACTIONS

Unsurprisingly, the nuclear industry and its supporters have reacted very negatively to the new draft. Strong nuclear advocates, in the state electricity utility Eskom, have gone so far as to defiantly declare that they will invite nuclear construction proposals before the end of the year.

But Eskom's defiance is unlikely to lead to anything substantial. This is because the state utility is facing both a credibility crisis and its finances are in poor shape.

On the other hand advocates of faster growth in renewables have criticised two fundamental assumptions underpinning the "base case" model.

They argue that the model assumes renewable tariffs slightly higher than achieved in the last allocations made under the renewable energy procurement programme. Only by 2030 do these drop a further 20% for photovoltaics and 9% for wind. But, given recent trends and projections, there's a strong likelihood that future renewable energy costs will be lower than that.

The "base case" also assumes a limit to how many solar and wind plants can be constructed annually. But based on past interest and delivery by private renewable power producers far greater annual developments are possible.

Several researchers have shown that by applying lower renewable tariffs and removing annual construction limits renewables can make up a much greater proportion of the energy mix. This means that the new nuclear might not even be needed in 2050.

FUTURE ENERGY DEMAND

The new energy plan is now subject to public input. It is due to be adopted by government in four months time after improvements and further scenario modelling has been added.

Even after adoption, updates will need to be done regularly (ideally every two years), since even current projections could be overestimating future energy demand considerably.

This is particularly true given that energy consumption is declining in most developed countries because of advances in technology and energy saving initiatives.

If the energy sector is managed correctly, the current South African energy crisis may not be as far reaching as is often assumed. wn

Premset MV switchgear

Because a reliable network depends on safe, flexible, and maintenance-free switchgear

Switchgear designed for enhanced peace of mind. Because business relies on the availability of electricity, buildings need their medium voltage distribution systems not only to be reliable, but also to be energy efficient, durable, and able to adapt to changing business needs. But the operators of these systems require more. Peace of mind is paramount, and can only be achieved with low-maintenance switchgear that helps ensure the safety of both people and assets. Switchgear that enables monitoring and lowers the total cost of ownership is critical.

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Resource consumption is one of the largest factors affecting your profitability and competitiveness. Material, labour and maintenance costs can be difficult to reduce without upsetting the delicate balance between product quality and process reliability. However, reducing energy costs and improving energy efficiency in your production processes is easier than you may think.

COMPILED BY I MINX AVRABOS

Energy insight to reduce costs and increase energy efficiency

Cost-effective technology provides energy intelligence to help you proactively manage energy consumption and operating expenses while supporting strategic decision making and best energy management practices. It will help you to increase energy efficiency, to fully utilise existing assets, and cut emissions without compromising output or product quality.

Enterprise-level software gives all departments information to help improve competitiveness. Production personnel can efficiently monitor and react to real-time power system information to increase productivity, improve process efficiency, and maintain reliability. Energy managers can identify waste, benchmark their facility and integrate energy management with business practices.

THE RIGHT PRODUCTS FOR THE JOB

A web-enabled system can monitor a plant, a nationwide business or a global enterprise through networked intelligent energy meters linked to software. Meters can be selected to match to the requirements of the location being monitored. They use flexible communications methods to connect to software that retrieves, aggregates, and processes meter data, logs it and notifies operations staff of alarm conditions. It can also integrate data from water, air, gas, electricity and steam (WAGES) meters, plus existing building and process management systems so you can incorporate energy efficiency into your industrial management systems.

It removes guesswork and helps you to discover which efficiency opportunities offer the quickest or highest payback potential. It can factor in cost variables such as utility rate schedules, real-time pricing, peak demand pricing and time-of-day usage and more.

APPLICATIONS COST ALLOCATION

Studies show that industrial energy efficiency is improved most when people have a stake in success. A software solution encourages energy efficient behaviour and supports cost accounting by accurately allocating energy overhead to different user groups or processes. You'll discover where and when energy is consumed and you'll be better able to motivate employees to meet corporate energy cost reduction goals.

Energy insight

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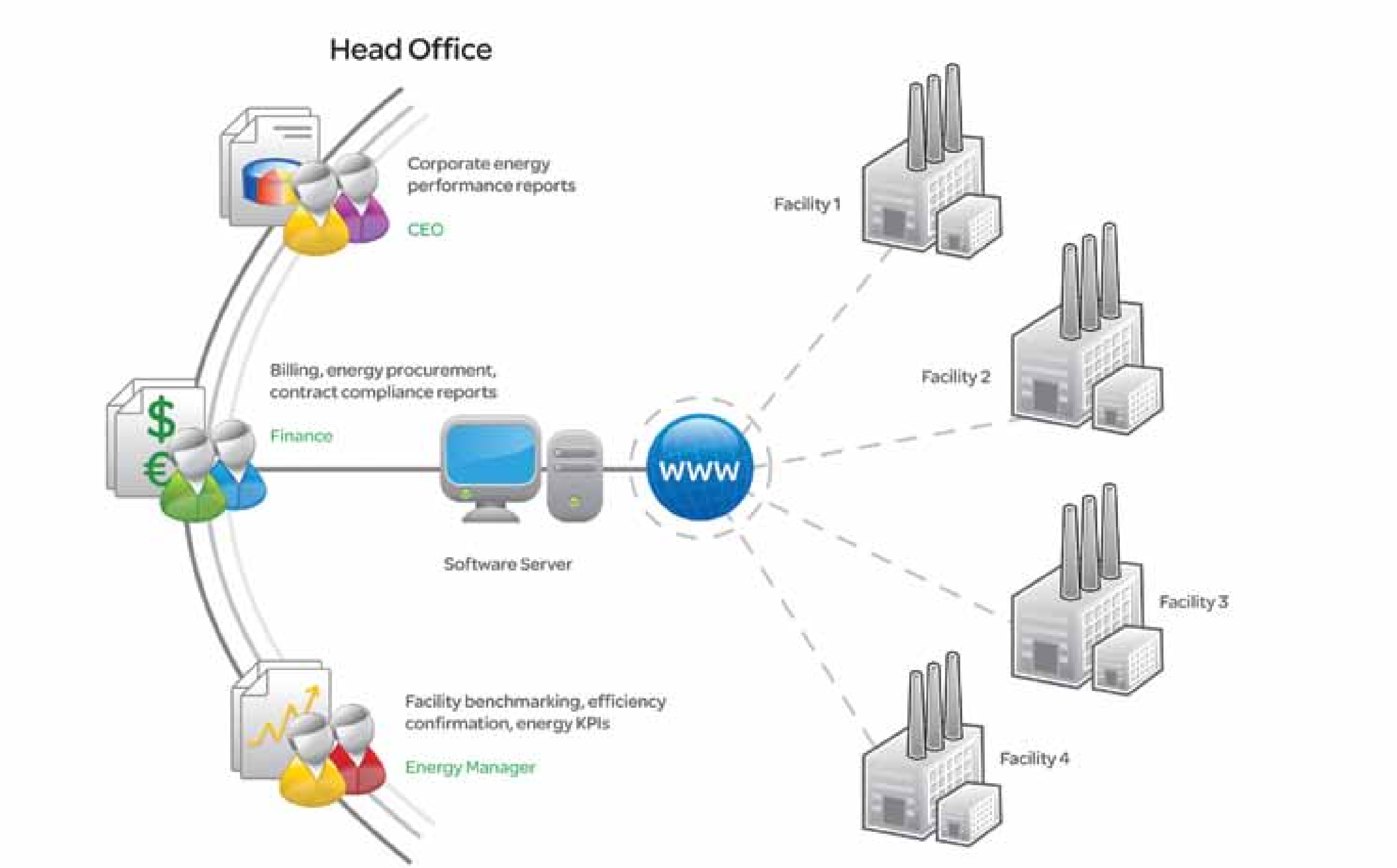


Energy information is collected from key locations and distributed to the people who need it

Software technology provides tools to:

- Automatically collect, calculate and report costs for buildings, departments, processes, shifts, lines, or equipment;
- Remove electricity budgeting guesswork, minimise administrative costs and reduce data entry errors;
- Determine the true impact of energy prices on all your production lines.

PROCUREMENT OPTIMISATION

Software technology will help you make more informed energy procurement decisions.

With a complete understanding of your energy profile, you'll be able to compare which purchasing options provide the most benefit. It can help you reduce long-term financial risks associated with price volatility, lower your costs through bulk energy purchasing and manage multiple energy supply agreements.

It technology also enables you to:

- Consolidate cost information into easy to understand reports;
- Participate in a spot energy market programs;
- Track real-time Internet pricing feeds;
- Automatically start generators or shed loads when cost thresholds are reached;
- Integrate costs for fuel, environmental levies, maintenance and interconnection.

POWER FACTOR CORRECTION

Your energy provider may penalise you for poor power factor, (a ratio of real to reactive power). PowerLogic technology helps you automatically manage power factor by alerting you to adverse trends so you, can take corrective action.

Use a software system to monitor power factor and control:

- Capacitor banks;
- Load tap changers;
- Filter banks.

MEASUREMENT AND VERIFICATION

Industry-standard Measurement and Verification (M&V) techniques assure your energy efficiency investments realise maximum payback for the long term. You can benchmark processes for comparison against internal metrics or industry statistics in order to identify the optimal places to target improvement projects. Key performance indicators (KPIs) help you measure progress and identify necessary adjustments to ensure sustainability.

The M and V capabilities of a software system can also ensure:

- You can benchmark against departments, processes and industry KPIs;
- Your results can be forecasted and compared with different benefit scenarios;
- Energy efficiency initiatives minimise negative affects to people or productivity.
- Results are documented so you can verify efficiency program financial benefits;
- Performance-based energy service contract results are verified to a baseline.

UTILITY BILL VERIFICATION

Small billing errors can be a large cost. Software technology helps you validate utility bills, document errors and measure energy supply contract compliance. Identify false penalty charges and authenticate the benefits of on-site generation.

INFRASTRUCTURE OPTIMISATION EXTEND EQUIPMENT LIFE

Well maintained equipment uses less energy, is more reliable and contributes to improved productivity. Software supports preventive and proactive maintenance for a wide variety of your energy assets.

- Determine the optimum timing and frequency of maintenance instead of using an arbitrary schedule;
- Automatically track the number of relay or breaker trips, UPS operations or charge remaining in batteries;
- Alarm on transformer temperatures, motor performance parameters and other wear indicators;
- Reduce effort and labour costs with proactive maintenance.

INCREASE RELIABILITY

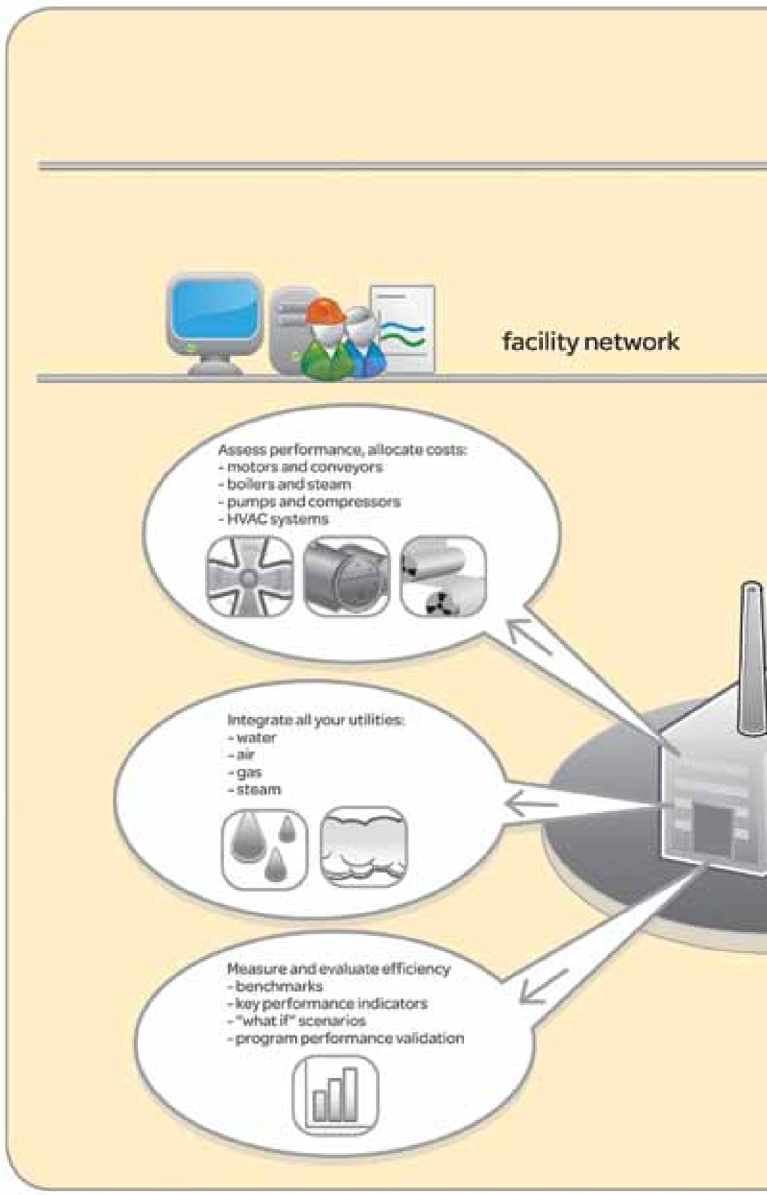
Downtime costs money. Power sags/ swells, transients and harmonics damage equipment and interrupt production. Software can help you:

- Identify the root cause of power quality issues;
- Rapidly communicate critical conditions before they escalate;
- Help coordinate backup power systems
- Decide if hamonic filters are needed and size them appropriately.

DISTRIBUTION SYSTEM OPTIMISATION

Minimise capital expenses associated with overstressing or under utilising your power distribution system. A realiable software system enables you to design a power system that meets but doesn't exceed the requirements of new facilities, expansions or retrofits.

- Design power systems according to actual usage patterns and accurate forecasts, not guesswork;
- Automatically generate load profiles to reveal historical and present load patterns and hidden capacity;



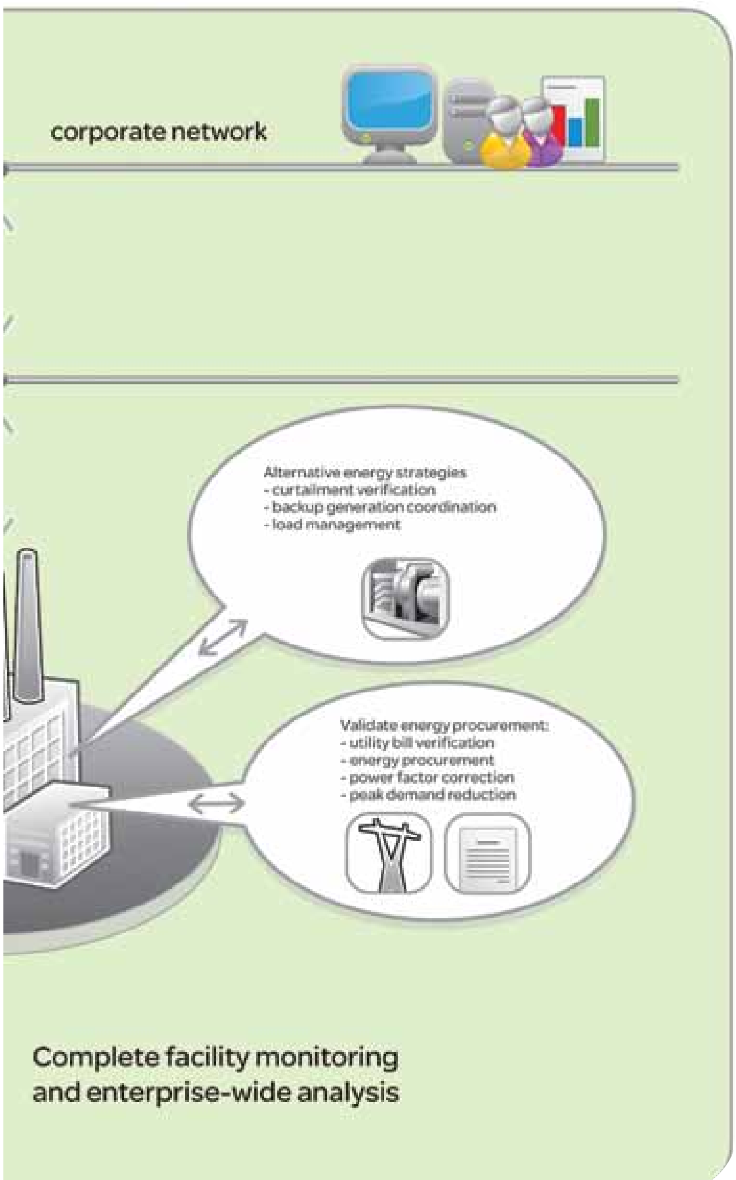
Energy insight

continues from page 27

- Determine if your existing infrastructure will accommodate new processes.

DEMAND RESPONSE AND LOAD CURTAILMENT

Demand response programs enable you to negotiate lower rates by agreeing to reduce loads in response utility curtailment requests. A reliable software system provides the timely load profile, forecasting, and cost analysis information you need to participate. It will first help you decide when participation is economically advantageous and where and how much load you may be able to reduce for each curtailment request.



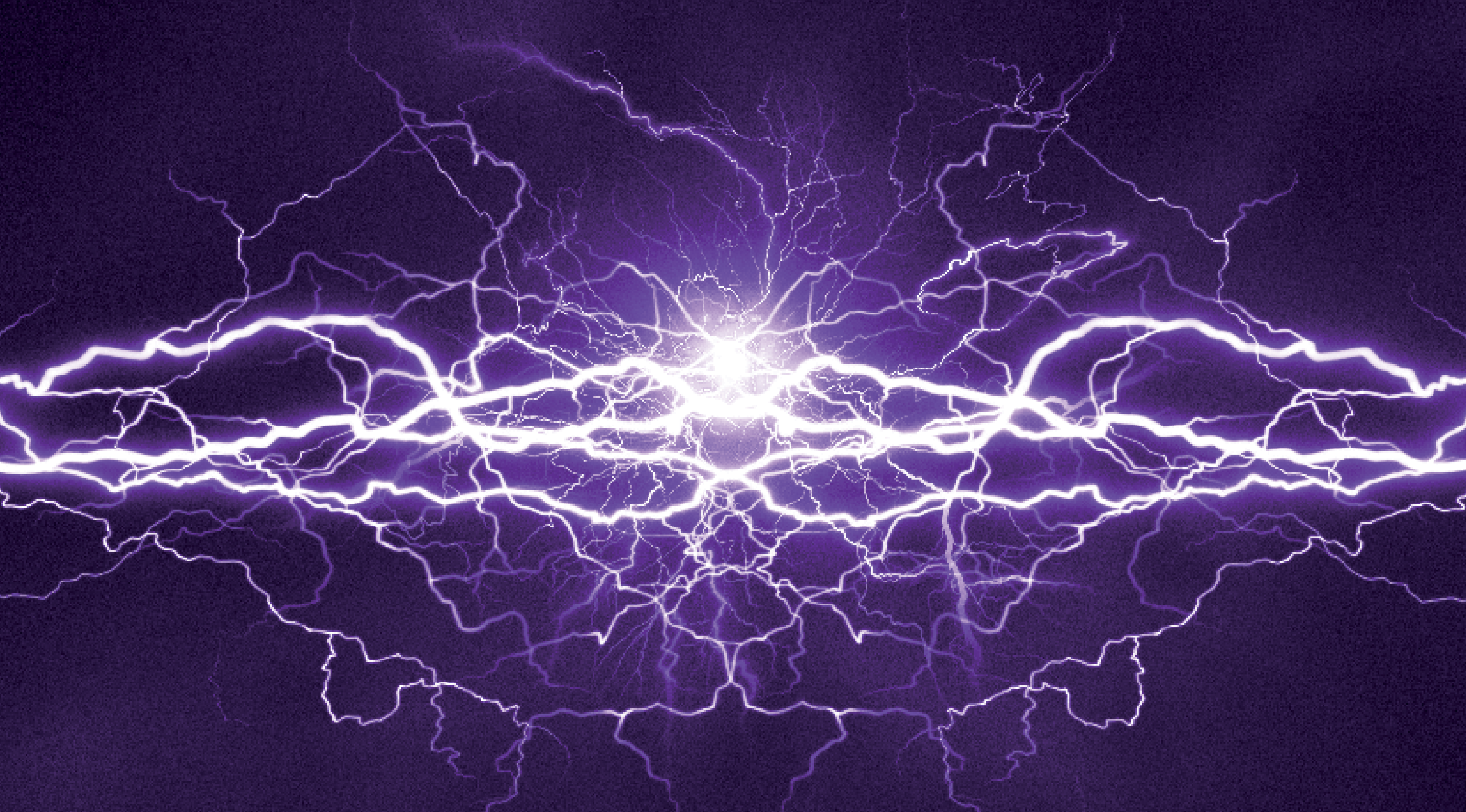
The right technology makes possible:

- Real-timeverificationofcurtailment;
- Coordination of backup systems;
- Remote, automated and aggregated load management;
- Contract verification to ensure compliance by all parties.

PEAK DEMAND REDUCTION

Reducing peak demand is one of the easiest ways to quickly lower your electricity bill. Software technology helps you "smooth out" your demand profile and avoid peak demand surcharges through:

- Automatic forecasting of energy consumption and demand;
- Alerts that warn you when demand thresholds risk being exceeded;
- Isolating specific power-intensive activities that you may choose to reschedule to off-peak hours;
- Automatic load shedding or on- site generation start-up;
- Sequencing of motor and HVAC to start- up to reduce instantaneous demand. wn

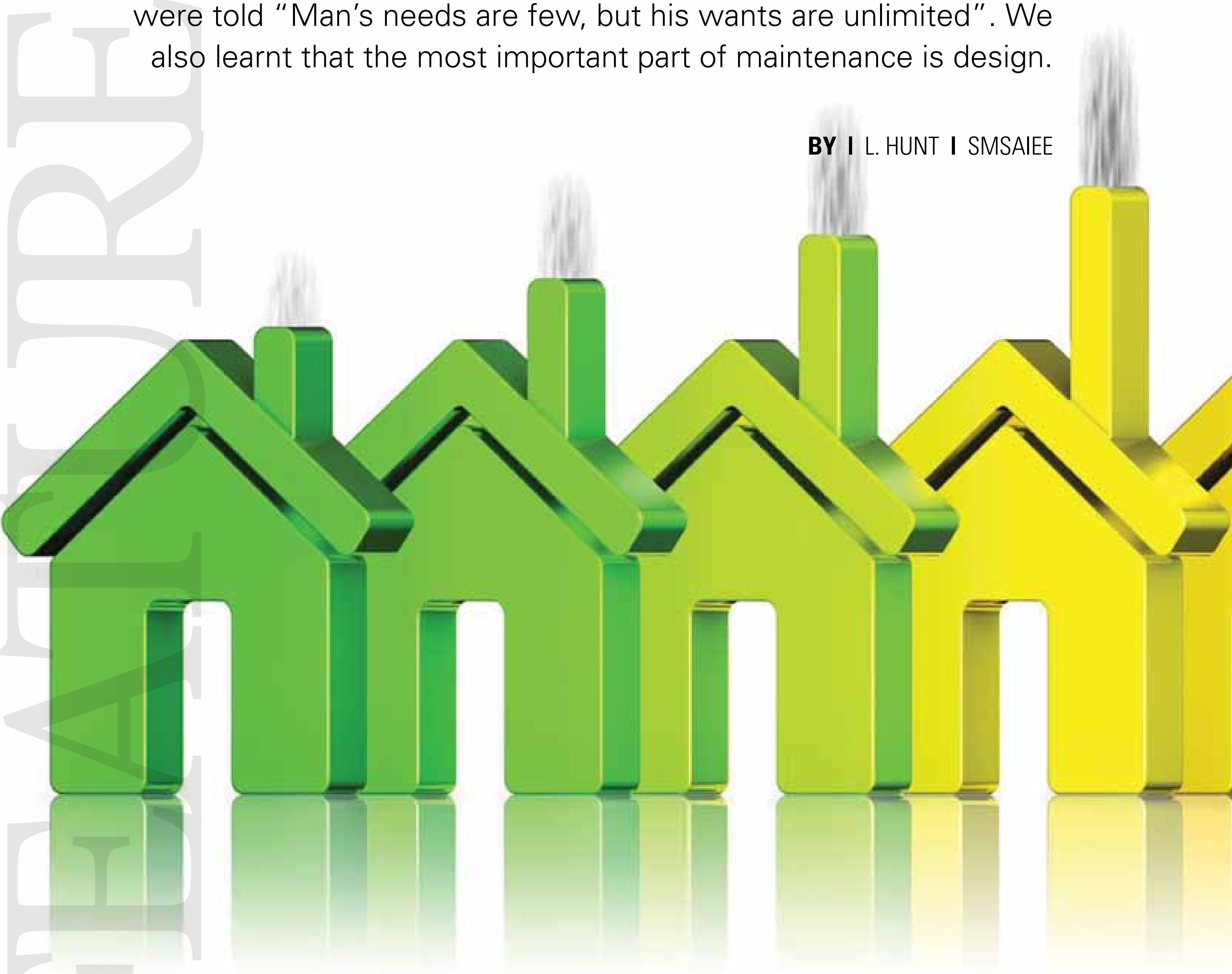


Energy use and abuse

Many years ago, at a lecture to the Work Study Association, we were told "Man's needs are few, but his wants are unlimited". We also learnt that the most important part of maintenance is design.

BY | L. HUNT | SMSAIEE

FEATURE



Let us look at our most basic need. Water: we tend to take it for granted that when we open the tap, potable (drinking) water will flow out of it. However, we seldom realise that the water we used had to be pumped from somewhere. This pumping required energy, which we got from the coal burning power-stations, and to produce that energy, so many grams of CO_2 were produced. If we waste water, we waste energy and add green house gases to the atmosphere. We also waste the chemicals for flocculation and treatment which were also produced while emitting CO_2 .

If we have to run water for some time before it becomes hot enough to shower, or to use for washing up, we waste energy, as well as the water used for cooling the turbines in the power stations.

When there is a long pipe run from the geyser to the tap, a lot of energy is wasted by convection and radiation from the pipes. Try measuring the volume of water you allow to run out before the shower is hot enough for you to step into, or before it is hot enough to wash the dishes, and remember that water had been hot when you last turned off the tap. Putting an insulating lagging on the pipes is helpful. Unfortunately, we can't put lagging onto pipes already in walls.

Replacing the shower head with an aerated head is claimed to save water and hence energy. At the Green Building Exhibition, I saw such shower heads which claimed to save some

Energy use and abuse

continues from page 31

2/3 of the normal water, but at high prices ± R600.

When the geyser is switched off, it slowly loses heat and, depending on the insulation around the geyser, more or less heat energy is lost. Putting a geyser blanket on the geyser reduces the heat loss, saving energy.

When Yvonne (my wife) and I toured in Spain and Portugal, some 20 years ago, we noticed a number of solar heaters on roof tops. But what we also noticed in Portugal, near a southern coastal port, was a power-station, fuelled by imported oil. When the price of crude oil quadrupled, this became a nightmare for the authorities. Spain subsequently passed laws that all new buildings had to have solar panels, and refurbished buildings likewise. It seems that something similar is contemplated in pending Green Building legislation. Energy Performance Certificates will become mandatory.

SANS 204 Energy Efficiency in buildings:-

- Part 1 General Requirements;
- Part 2 Application of EE requirements for buildings with natural environmental control;
- Part 3 Application of EE requirements for buildings with artificial ventilation or air conditioning.

Solar panels have already been in use in Australia and Israel for more than 50 years; and Australia have been subsidising the installation of solar panels. Solar collectors come in two main classes:- 1) those in which the water being used passes through the panel to the tank by thermo-siphon, and 2) those where an intermediate transfer liquid is used; a) to avoid freezing and; b) to avoid corrosion or scaling in the collector.

When we lived on a plot, I installed two solar panels, each containing some 125 litres of water as pre-heaters to the geyser, thus saving substantial heating energy.

It is recommended that a minimum percentage of 50% of hot water requirements be obtained from a renewable source. It is estimated that an effective collector system can save an average householder more than 30% of electrical energy.

The angle of inclination of a collector should be latitude + 10˚ . Collectors should face true north or slightly west of north. A deviation of 45˚ east or west of north is acceptable but less efficient.

DEMAND REDUCTION

1. A geyser takes a considerable load, and relays can be fitted so that when a stove is switched on, the geyser is switched off.
2. In order to reduce system demand, remote-controlled relays can be installed in our homes, so that supply authorities can switch off geyser loads from a central control point. This helps to avoid an outage when the load rises too high.

When I was experimenting with solar energy in Vereeniging some 55 years ago, I learnt some vital points:

- My storage tank of some 30 gallons (136 L) could cool off within 30 minutes after sunset without insulation;
- With one layer of glass, a certain temperature could be obtained, with two layers of glass higher temperatures were obtained. Of course the upper layer of glass had to be hail resistant. (The modern vacuum tube collectors obviously have 2 layers of glass, with vacuum between.)
- The space between the glass and the collector surface needed to be small, and cross baffles were useful in preventing convection currents from cooling the interior.
- For a matt black surface, I used blackboard paint. There are much better substances today.
- For the collector itself, I used a corrugated galvanised sheet onto which was riveted a flat galvanised sheet, bent up at each end to form water channel headers, and the edges were all soldered for water-tightness
- The tray in which my solar panel was mounted had exfoliated vermiculite for thermal insulation but these granules tended to migrate down the slope.

The cost of making these solar panels was too high when compared to the price of coal, which was generally in use at that time, or the price of electricity. With the current high prices for electricity, and the need for reduction in green-house gases, the economic picture has changed.

At the exhibition, I saw various solar panels. However, the most interesting was one in which the collectors are elongated glass vacuum flasks, with a copper tube down the middle, supported by a formed metallic holder, and coated with heat absorbing paint. Each tube end could be inserted into a header, above which carried the circulating liquid. It was claimed that the glass tubes were hail-proof.

Another very worthwhile system uses heat pumps, to circulate liquid through an underground pipe system, to either abstract heat from the ground, or lose heat to the ground as the seasons dictate, by means of a heat exchanger working as if it were a refrigerator. This can be used to

heat water in geysers, while cooling air in air conditioners.

In the new Fairlands Building north of Johannesburg, solar heating for all geysers has been installed right from the start. Bleed-off water from air conditioning cooling towers is collected and stored for later use for landscape irrigation.

If we all installed rain water tanks, and used this water for the gardens, this would also save energy and green-house gases, as well as attenuating run-off. This would reduce flooding and place less load on the storage dams and storm water drains.

At the Green Building Symposium, we were told of the re-use of grey water for gardens and toilets.

LIGHTING

Fluorescent lights, and in particular compact fluorescent lamps, use less energy than incandescent lights, and there is a world wide attempt to eliminate all incandescent lights, as the fluorescents last much longer.

However, fluorescent tubes and CFLs have one problem, they all contain a small amount of mercury, and should not be thrown out in the normal rubbish containers. Special reception depots should be established for the safe handling and transporting of these toxic wastes.

High intensity discharge lamps also contain mercury, and should be treated in the same way.

Electronic ballasts are now being used in place of the previous electromagnetic ballasts, which also wasted energy.

Heat generated by lighting also contributes to building heat, which has to be dissipated via air conditioners. In one supermarket, I saw some 20 rows of 20 light fittings, each with two 40 watt tubes, hence 800 x 40 = 32,000 watts or 32 kilowatts.

Running those for 12 hours per day = 384 units per day, at R 1 per unit x 30 days per month, this costs R11 000,00 per month. That heat produced requires additional energy for air conditioners to cope with its dissipation, all at extra expense.

When we look down on a town at night from the surrounding hills, or an aircraft, we see a huge amount of light, so remember that light is energy, and all that light going upwards is wasted energy.

Controlling illumination levels in buildings can be done by dimmers, some of which will sense human presence or absence, and will dim the lighting to suit. This is helpful when Daylight Harvesting is planned for. Dulux offers a light reflective paint.

In the new Fairlands building, North of Johannesburg, the façade also features horizontal and vertical sun screening, enabling the maximum use of natural light with minimum glare.

New lighting in the form of LEDs (Light Emitting Diodes), is being introduced, and is much more effective both in energy efficiency, and long life, than any other means so far.

Some of these are already being installed in traffic lights. It is hoped that the price can be reduced for general use in the future and units made to fit directly into existing sockets.

SEWAGE TREATMENT

Sewage plants of the past used bio-filters and solids treated in gasifiers to produce energy. Today many such works use surface aerators, which use tremendous amounts of energy. Fine bubble aeration, or submerged venturi aerators are much more efficient, saving as much, or more than 30% of energy required

TRANSPORT

Much has been said about electric cars, but these will only really be reducing pollution when they are fuelled by hydrogen directly, or in fuel cells.

In a May issue of **watt**now, Viv Nel gives the following typical, but approximate figures;-

- coal is used to fire boilers to make steam to power turbines to rotate alternators to generate electricity. The overall energy efficiency about 35%;
- Electrical transformation and distribution efficiency about 98%;
- AC to DC conversion efficiency to charge batteries – 90%;
- Batteries are now used to drive electric cars: chemical to electric conversion 95%;
- Giving overall input to output efficiency +/- 26,13%;
- Some internal combustion engine have an efficiency of around 30% max.

While the overall efficiency of a car fitted with an IC engine can be as low as 15%, but often is of the order of some 23 to 28%. So it would seem that the IC engine will be with us for some time yet. (My son's Corolla diesel gets 20+ km per litre on a long run).

The conversion efficiency of SASOL liquid fuels from coal has been stated at 36%. Using this in a petrol engine at 25%

Energy use and abuse

continues from page 33

efficiency, we get 0,36 x 0,25 = 9% overall. However, one favourable aspect of electric cars is that we would not have to import so much petroleum, needing foreign exchange.

If the excessive amount of freight carried on our roads by heavy trucks could be carried on the railways, using locally produced electricity, a substantial amount of foreign currency would be saved, which could be used for other projects. The same goes for electrically driven trams and trolley busses, which are now out of fashion here, but still in use in many overseas countries.

There are a number of sources of alternative energy.

SOLAR

Solar water heaters on buildings are the most obvious and practical saver of energy. Solar Voltaic cells for charging batteries, from which inverters can convert the DC to AC for power purposes. Some are being used at traffic circles and street lights to avoid disruption when power outages occur.

Solar energy concentrators which will boil water to run turbines generating electricity. Of course, this electricity is only available during hours of bright daylight, and some of it has to be stored for use at night.

Wave power and tidal power are being used and researched for better efficiency.

WIND POWER

We are all familiar with windmills used for pumping water from underground, which uses a reciprocating plunger pump. A recent innovation is the Turbex windmill, which turns a shaft running down to a screw pump below.

On a farm I visited recently, the farmer had a generator mounted way up the windmill tower, driven from this shaft and being used to charge a set of batteries, which supplied his house. To cut down the load, he was using gas for water heating, and a gas stove for cooking. Siemens claims to have installed world-wide wind turbines with a total capacity of 7,000 MW, and are installing the worlds largest onshore wind farm of 322 MW in Scotland.

When my brother and I were on tour, we saw the 4 wind turbines at Darling in the Cape, but they were all standing idle. I read recently that they are running again, as are many new units at wind farms. Vertical axis turbines are now being used for smaller demands, such as within towns and residential units.

WATER

Hydroelectric power is a very nice clean form of energy production, but is dependent on large supplies of water. While on tour, we saw the Vanderkloof dam, at the bottom of which is a hydro electric powerstation. However, this is small in comparison with any unit in any of ESKOM's thermal stations.

Pumped storage schemes are being used, and more are being built. This is where water is pumped up to a large, higher-level holding dam during periods of low electricity demand, and then run back down the tunnels to cause the pumps to act as turbines and generate power when peak loads are being experienced. This helps to balance the load on the power stations.
As a result of the severe drought, many dams in various countries are so low that they cannot continue to produce a reasonable supply.

ATOMIC ENERGY

Eskom has two 900 MW units at Koeberg, and our own great fairytale, the Pebble bed modular reactor, which we have been hearing about for many years. If this ever gets into production it will not only give electric power but also be a valuable source of Hydrogen production, which could be used directly in internal combustion engines or in fuel cells to power motor cars.

Thorium is being researched as a preferred fuel source for such a reactor, and seems very close to commercialisation in Norway and China.

GAS

When we lived on a plot, Yvonne used a small gas stove for cooking. The roasts she made in that gas oven were the best! Gas has been used for cooking and lighting overseas for generations, and can even be used for refrigerators, such as we used on our Parys farm.

Gas driven vehicles are not new, and many fork lift vehicles in factories use bottled LP gas for their engines, producing less pollution than petrol or diesel. Biogas can be produced from cattle dung on farms and used for kitchen purposes. This process was being used in India many years ago.

Gas is also derived from rubbish dumps via collector pipes underground. As far as I know there are two such sites in Natal. In some of the older sewerage works, using what is known as bio-filters, the solids are fed into digesters, and produce gas which was used to power engines to run the plant. This is starting to be used again at the Gauteng Northern Waste Water Treatment Works.

BUILDINGS

There are many considerations for building design and placement. Prevailing wind, soil conditions and annual and daily temperature variations are all factors to consider before building.

In one project in Dubai, the designer placed two buildings side by side but with sufficient space apart in order to put wind turbines on bridges between the buildings. These are generating electricity for use in the buildings.

WALLS

Thick dense walls can be a source of attenuation of temperature. Hollow walls come in many forms. Most of us will have seen bricks with 3 holes in them. The house in which I live has bricks with some 2 rows of 5 holes in them. In Portugal, I saw building walls of hollow clay tiles, and hollow clay tile beam fillers. These are useful in preventing too much heat transfer through the walls.

CLEAN ENERGY EFFICIENCY AND GREEN BUILDING CONCEPT

At the Green Buildings Conference, speakers commented on the relevance of the topic to SA:

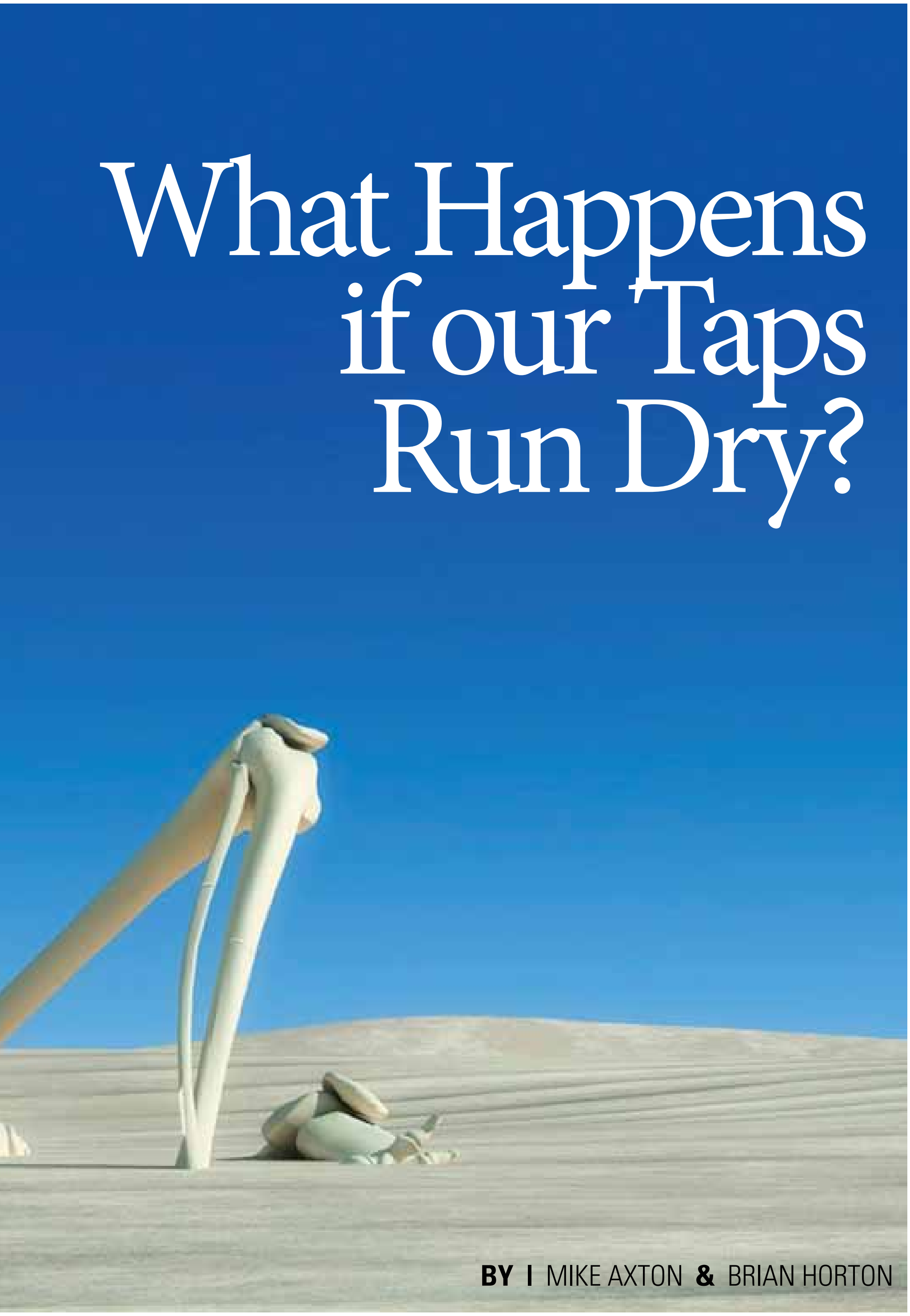
- To define standards for the National Estate
- What defines a Green Building
- To define technology, process and systems
- To establish eco-friendly homes and villages
- To find a balance and harmony between man's needs and nature, to meet emotional needs, and make a covenant with nature
- The ethics of creating a better way of life

During our discussion on CFLs, some complained of the much poorer illumination of the CFLs. Others living on farms said that they had lost so many CFLs due to spikes in the supply that they could not afford to continue replacing CFLs at the high cost. Questions were raised as to exactly where old units could be disposed. wn

Earn CPD Credits

In the developed world, expectation is nothing less than a right. We open the tap, and we expect clean drinking water to flow. We switch on the lights, and bulbs must illuminate. We swim in waterways that must be safe and free from bacteria.

What Happens if our Taps Run Dry?



BY | MIKE AXTON & BRIAN HORTON

Many resources that are critical for life are taken for granted, with little regard as to how the water came to be in the tap, or how the power got to the bulb.

They are regarded as an entitlement. But beneath the surface, hidden and unseen, lie literally hundreds of thousands of kilometres of pipes and wires, connected by a myriad of pumps and valves all pulsing away in real time, in the most intricate interconnected web that make our cities habitable. Decades of planning, engineering, sweat and hard labour have been invested to provide these precious commodities, and the tide of demand is rising ever higher.

It's often said that we don't realise what we have until it's gone. This is perhaps how some of the 1,7 million residents of South Australia felt the evening of 29 September 2016, when severe storms toppled power transmission towers and left their state in darkness. The infrastructure that ensured the steady provision and flow of electricity went largely unnoticed and unappreciated, until it was no longer doing its job.

The resource supply systems undergirding our cities are currently pressed from numerous sides.

Many cities are facing the real possibility of a perfect storm that will push their infrastructure close to breaking point unless a radical shift in thinking is embraced. The confluence of our insatiable appetite for urbanisation coupled with an unpredictable climate, all superimposed on infrastructure that is decades old, is demanding new thinking.

Ongoing demands for upkeep and expansion have an eye-watering price tag. Water infrastructure is a multibillion-dollar asset that, if we were currently to overhaul and redo, would likely drain an entire city budget. Sydney alone will spend $2.2 billion on water infrastructure in the next four years.

As the tidal wave of urbanisation increases in the coming 20 years, how can Governments and water authorities manage the compounding pressures on limited resources, coupled with the adverse effects of climate change? The public purse and taxpayer pool will have to somehow satisfy the living standards and expectations to which communities have become accustomed.

What happens if our taps run dry?

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About 40% of the world's population currently lives in water-stressed areas. With three billion more people added to the planet by 2050, water scarcity will soon become a matter of life or death. We face lower and lower tidemarks on our water supplies.

The world of water in a decade's time will see people expect exactly the same level of service (if not better), yet the problem will have grown in complexity. More pipelines are only a part solution. It's a paradigm shift that's called for: the utility authorities will need to change people's behaviour through better digital interaction with water.

If we fail to address the social mind sets driving city planning up until now, our problems will only get worse. But if we can use the digital world to sidestep this static analogue problem, we can turn crisis into opportunity.

Digital technology allows us to step back and 'smart up' around the current cycle of water consumption and wastage. We can begin to see the grim reality of limited supply as the 'dark room' of innovation, whereby bold new ideas can be born to secure societal welfare in future uncertain times.

MOVING FROM POINT A TO POINT B

Up until now, we have lived in an analogue-based society. Our infrastructure is essentially 'dumb', marked by physical variables that function independently of one another. But as digitalisation and mobile technology continue to evolve at pace, the systems and spaces we inhabit will begin to catch up.

Autonomous vehicles represent 1% of the automotive market worldwide today, but autonomous vehicles will secure a 35% advantage by 2040, and that will continue to rise.

Equally, the flow of water through a city's network of steel and copper waterways will someday be analysed and controlled by smart grids. Our analogue world will become digitised; we will cross over. But where does this leave our clients today, when we stand on the precipice of change and don't see a bridge in sight?

Our job is to build that bridge through digital transformation. Our current 'unintelligent' analogue systems must be progressively transformed, if we are going to change user behaviours through their enhanced interaction with the precious resource they are consuming.

Real-time predictive analytics can draw the best out of our limited water supply by offering simple, intuitive, and meaningful insight into unique infrastructure. This, in turn, can be transferred into optimal and cost-effective management strategies that keep the water cycles healthy.

GETTING ONE STEP AHEAD

Installing predictive maintenance applications can feel at times like a Herculean task.

But statistics alone present a convincing argument that motivates a speedy change of gears into digital integration. While the demand for freshwater is increasing by 64 billion cubic metres annually, the U.S. alone loses 2.1 trillion gallons of treated water every year due to pipe breaks, leakages and mismanagement. This economic loss amounts to trillions US $, with a downward chain reaction on food prices, health and sanitation.

Connecting these assets into a real-time monitoring network will reduce the time it takes to discover and solve problems that historically appear only when they literally surface. That same data can be applied as red alerts to motivate preventative maintenance and mitigated risk into the future.

Smart meters, high-tech leak detection devices and water data software are starting to offer sophisticated and granular information on how to maximise profit, impact and environmental sustainability within water management and distribution systems. The municipalities who are taking heed are gaining traction in the future-ready race.

CONTEXTUALISING THE ISSUE

The 'magnifying glass' or micro approach to problem solving is no longer viable within the context of our interconnected digital world. If we don't contextualise the water crisis under the bigger themes of climate change and urbanisation, we could solve a water problem, while unintentionally creating an economic one.

Our water problems will not ultimately be solved by throwing water solutions at them. Water cannot be seen as an isolated utility, but an integrated variable in the quest to solve societies' major problems. If we are to ensure this precious commodity's sufficient supply into the future, we have to adopt new ways of thinking around our capability and responsibility to steward the resource. Smart cities are the only solutions with shoulders broad enough to buffer the oncoming high tide of overpopulation. wn

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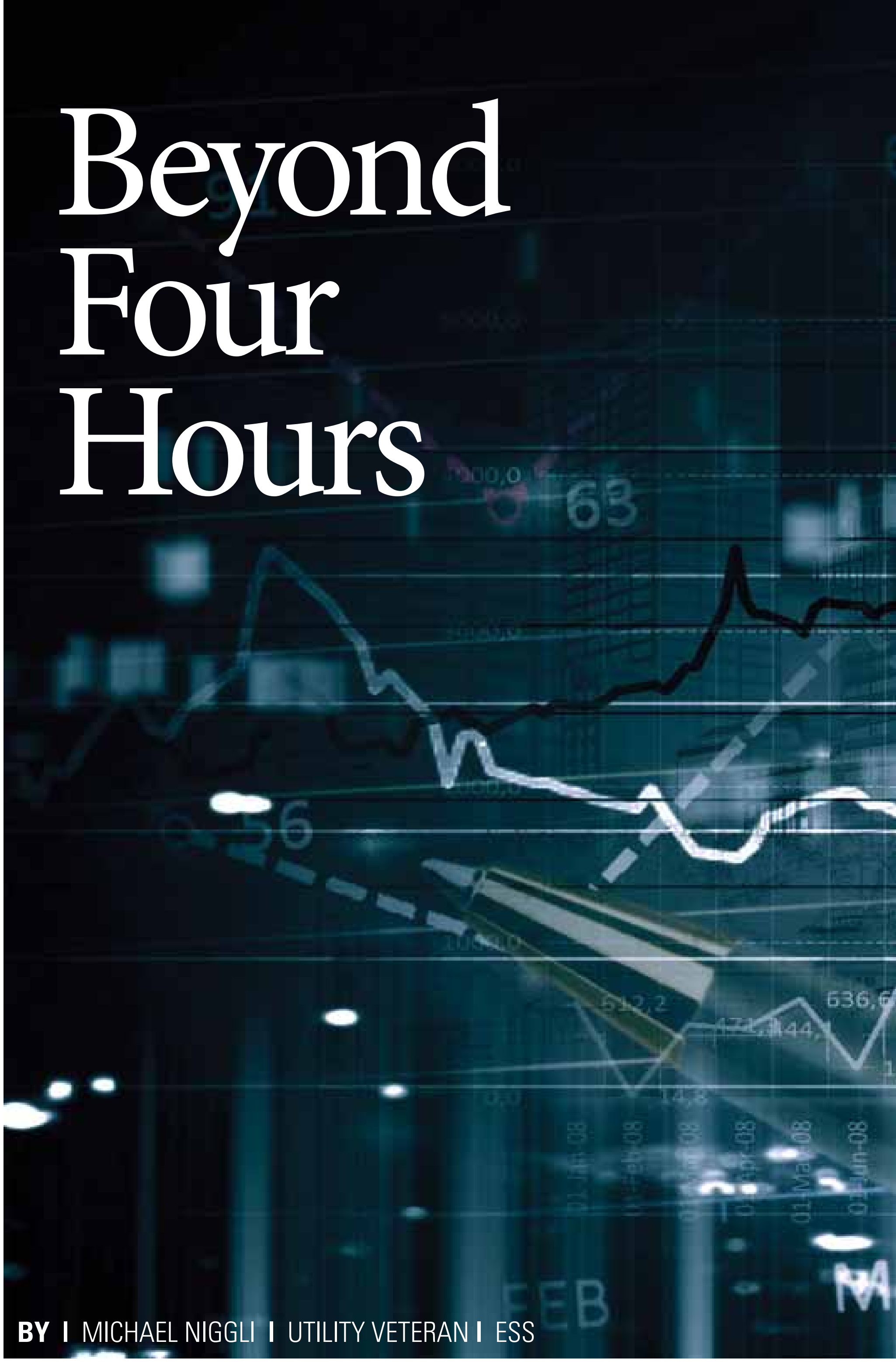
FEATURE



Beyond Four Hours

This article aims to capture and foster current thinking on new and emerging use cases for electrical energy storage, and in particular the growing need to combine energy and power applications into a single exible and valuable long-duration storage asset.

BY | MICHAEL NIGGLI | UTILITY VETERAN | ESS

This market evolution is signifcant because it increasingly requires storage asset developers and owners to look to new battery technologies beyond the lithium-ion battery chemistries serving the short-duration applications deployed so far.

I have worked in the utility industry for four decades. I've watched our market evolve and grow. But I've never seen change on the scale we are seeing today.

The advent of largely distributed generation of intermittent renewable energy is gradually tearing up the rulebook we have built our businesses on. That's a challenge.

We don't like uncertainty. Our job is to keep the lights on, not experiment with the unknown. So when we're forced, either by regulation or market shifts, to change our ways it is natural we should do so in a guarded fashion.

That means sticking to what we know best. Substituting just one thing at a time. Checking to see if it works, then moving gradually on to the next thing. So it is with storage.

Here is something with an obvious attraction for our industry. A way of taking the edge off intermittency. A tool for ancillary services that won't add to our carbon woes. A hand with everything from black starts to infrastructure deferrals.

Yet storage is costly, and it's not something we are used to. I believe we have chosen to embrace it at an appropriate pace: one application at a time, but with growing enthusiasm.

I see my industry colleagues involved in lively discussions over deployment of storage for a whole host of applications. We're seeing the business cases make sense and the use cases pile up. And yet...

We're still just scratching the surface. Our battery arrays today can help us for seconds, minutes, maybe a couple of hours. But what will happen as our renewable penetration grows and our fossil-fuel plants close down?

The current duration levels of storage will no longer do. That is why I think we need to start looking at the next frontier for electricity storage: that which can take us

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to at least four hours and beyond. This is somewhat uncharted territory for us.

Energy storage technologies and applications have always been defined by two essential factors: rating and duration.

Historically, energy storage has focused on bulk energy management, with pumped hydro still making up around 90% of all capacity installed worldwide.

Recent increases in the level of grid-connected intermittent renewable generation have, however, switched the attention of utilities to the need for seconds-to-minutes energy storage of up to megawatt scale, mostly for power applications.

The technology of choice for these short-duration applications is lithium-ion (Li-ion) batteries, which accounted for 99% of all grid-tied storage deployments in the second quarter of 2016, for example.[1]

Nobody disputes the suitability of Li-ion for such applications, which in some cases may extend up to two and potentially four hours.

However, there is clear evidence of growing market demand for more flexible, mid-to-long-duration applications that Li-ion is not technically and economically suited to. For example, since 2015 France, among other nations, has been actively looking into the deployment of renewable energy microgrids incorporating higher-capacity energy storage resources across its offshore dependencies.[2]

At the same time, power-hungry off-grid mining operations are starting to look to storage plus renewables as a way to reduce their costly and risky dependency on diesel generation.[3]

Meanwhile in certain US territories, and most notably Hawaii, there is increasing interest in community-scale energy self-consumption because of the elimination of net metering along with a growing penetration of renewable generation.

These kinds of energy applications cannot usefully be served with the kind of short-duration storage assets we have seen in the market to date. And the need to extend the duration and exibility of storage assets is only going to grow.

Bloomberg New Energy Finance predicts that by 2024 renewable energy will have reached significant levels of grid penetration in many key utility markets, from 29% in Germany to 39% in California.[4]

At these levels it is reasonable to assume a need for signficant levels of long-duration storage (LDS) for renewable energy integration tasks such as load shifting, time-shifting renewables and smoothing intermittencies.

Generally speaking, we can expect to see a growing opportunity and requirement for project developers to provide energy and power applications within a single asset, thereby extending the value of storage.

Bloomberg also predicts a growing volume of behind-the-meter storage, which could likely be aggregated for grid services and may well be configured to deliver multiple hours of discharge as a way of cutting electricity bills.

WHAT FORM OF LDS IS MOST SUITED TO THESE TASKS, THOUGH?

Further widespread use of pumped hydro is problematic because of the massive upfront costs associated with the infrastructure, plus the need for very specific geographical locations in close proximity to transmission lines.

Southern California Edison is deploying Li-ion batteries for up to four hours of storage[5] to replace capacity impacts from the loss of gas storage at the Aliso Canyon facility.

The record-breaking speed of the tender and deployment timeline reduced the options to the only available commercial choice at this time: Li-ion.....but that is changing quickly, and more options for longer duration energy storage are clearly on the immediate horizon.

It is worth noting the contract is limited to 10 years, to account for capacity fade-out issues. In any case, four hours is generally accepted to be around the upper limit of duration for Li-ion technology.

Li-ion also suffers from other shortfalls, including safety issues, notable performance degradation and a maximum lifespan of no more than around 10,000 cycles, which have a significant impact on the full life-cycle economics of a project.

However, currently there is little research into what happens beyond the four-hour limit and the power applications that Li-ion is being used for.

This article aims to supplement the lack of current information and document current attitudes to and thinking around LDS.

DEFINING LONG DURATION STORAGE (LDS)

Although there is no clear agreement about how many hours of duration or capacity LDS should provide, the largest proportion of respondents see it as having to be capable of at least four hours of storage (figure 1). When commenting on their own business's needs, a four-to-six hour capacity was most commonly mentioned.

CURRENT IMPORTANCE OF LDS TO UTILITIES AND DEVELOPERS

Almost all of the utilities and grid-scale energy project developers surveyed are conscious of a growing need for LDS, with approximately one in three seeing it as very important to their current business models (figure 2).

"Every one of our clients needs it."

Respondents from all parts of the world see a need for LDS technologies, although across all there is an acknowledged and much clearer focus for now on short-term storage, for example for enhanced frequency response in Britain.

"I think it is an important opportunity for future business development."

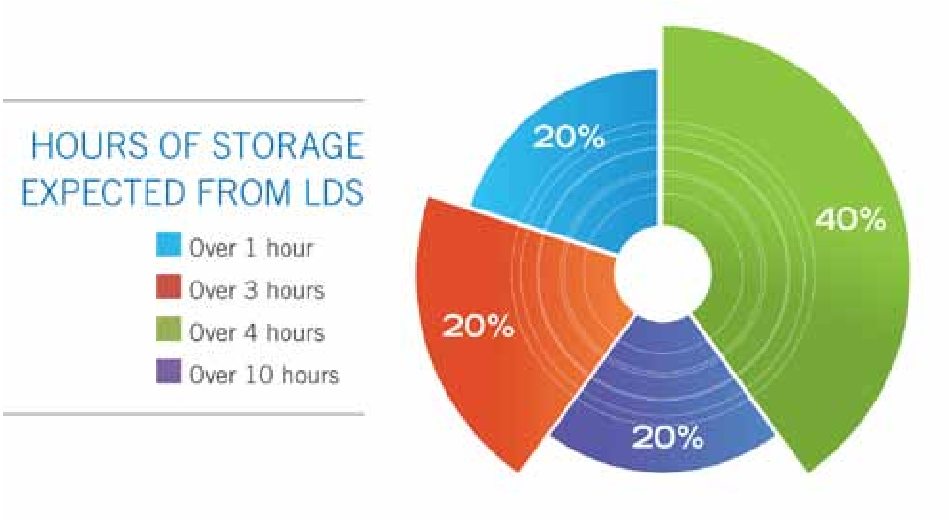

Figure 1: How many hours of capacity is LDS?

CURRENT APPLICATIONS FOR LDS

One of the biggest drivers of value in energy storage projects has been found to be the ability to 'stack' several applications onto a single exible, and long operating-life asset. Short-duration battery technologies such as Li-ion are able to fulfil a number of individual functions but are challenged in terms of lifecycle cost when faced with situations requiring frequent cycling and longer-duration discharge requirements. To investigate the boundaries of short-duration storage applicability, respondents were asked where they might use or foresee using LDS. The most frequently mentioned current reasons for using LDS are:

- To avoid duck curves in areas where there is an increase in an already high level of intermittent renewable energy sources such as solar and wind.
- For grid-tied community or commercial and industrial microgrids, where storage can be attached to renewable generation for grid resiliency.
- For grid constraint management, especially demand and supply shifting to avoid having to pay for new transmission infrastructure.
- In island and remote microgrids.

As well as utilities needing LDS themselves, some respondents think their commercial

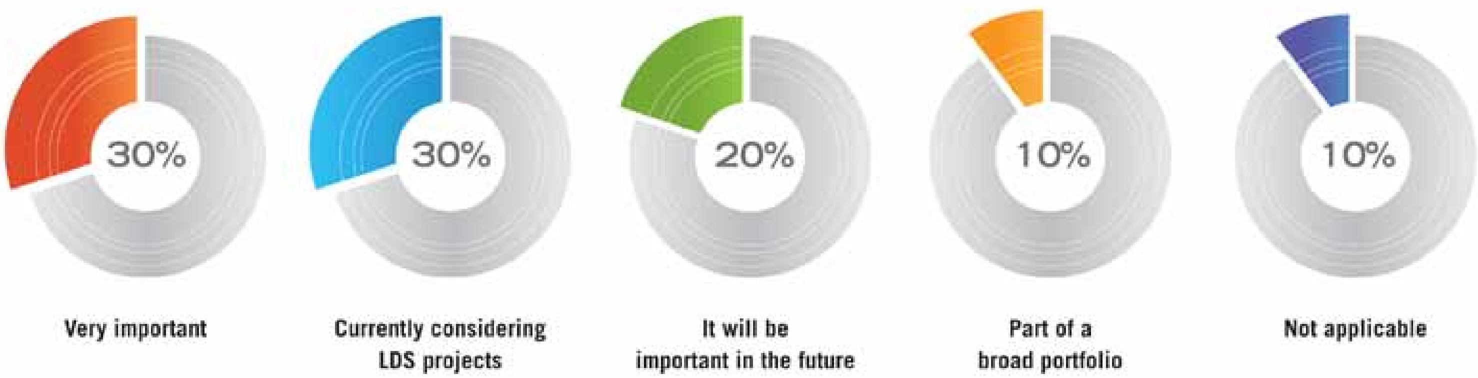

Figure 2: How important is LDS?

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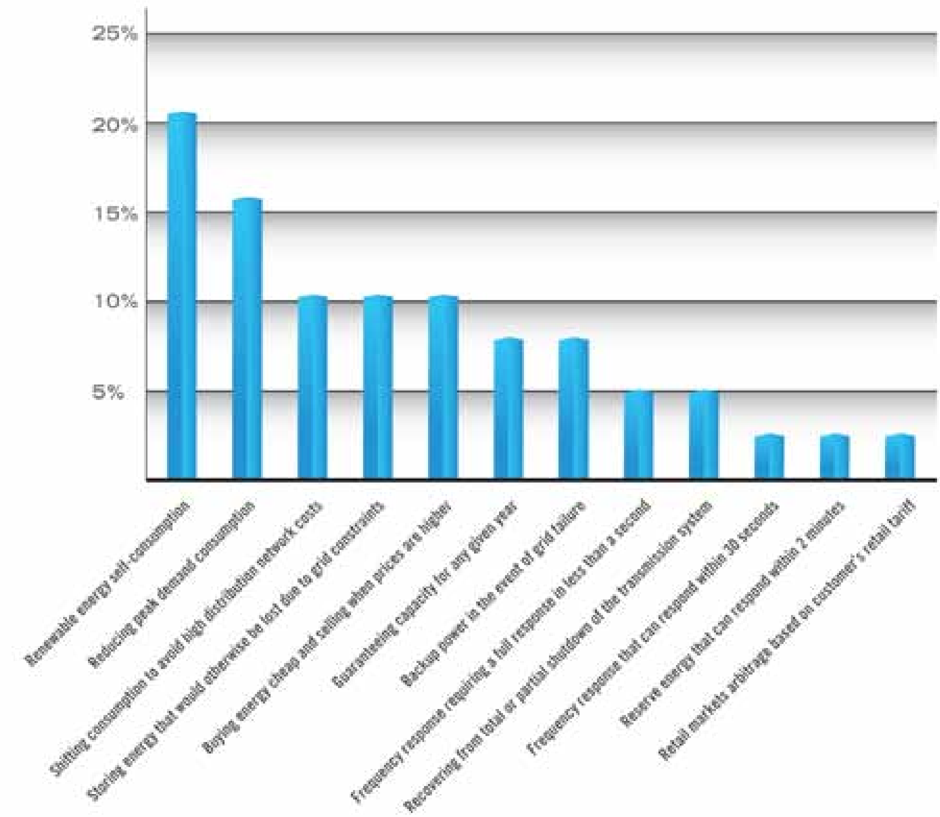

Figure 3: What LDS deployments offer the greatest potential for return on investment?

and industrial customers will adopt four-to-six hour storage as a way of avoiding the high cost of peak energy.

Depending on market structures, this could allow commercial and industrial customers to take advantage of up to three business models:

- Using storage for rate-based arbitrage in places such as New York City, which has deregulated time-of-use rates, to reduce demand charges.
- For increased self-consumption and peak-tariff avoidance in places such as Germany. • To get around net energy metering limitations.

LDS is already being used behind-the-meter for load management in New York City, where the ability to store cheap and efficient base-load power at night can help overcome generation and transmission constraints in the day.

This finding chimes with the trend towards behind-the-meter storage deployment identified by Bloomberg New Energy Finance.[6]

CURRENT CONCERNS ABOUT IMPLEMENTING LDS

The largest concerns that respondents have about using LDS in projects relate to uncertainties about costs (both upfront and levelized) and technology bankability.

"LDS will mature and drop in cost in the next two to three years, so it may be better to wait." Some feel that business cases for LDS are not proven yet, since there is little practical experience. And they are unsure about the value LDS could generate or whether they would be able to cover the costs of implementation.

Five factors can be seen to be at play here:

- Storage purchasers are aware that the business case for new assets cannot be built on costs alone. A critical question when evaluating any storage technology is not just "how much does it cost?" but also "what value can it deliver?"
- Even when focusing purely on cost, there may still be a certain amount of caution regarding LDS simply because some technologies only have a limited track record on long-term operations and maintenance.
- All forecasts lose accuracy as they extend into the future, and to minimize this risk there may be some wisdom in looking closely at options where capacity or efficiency degradation are known to be minimal.
- Today's storage revenue streams may not be those that apply 10 or 20 years from now, so it might make sense to select storage options that are exible and can cover as many potential use cases as possible.
- Long-duration storage has the ability to provide substantial exibility in dealing with ever-changing regulatory and legislative landscapes, not to mention commercial volatility.

Some respondents expressed a perhaps understandable uncertainty about using new technologies.

Also, with one of the major potential uses of LDS being as part of remote microgrids, there is concern about the maintenance that systems might need over time.

This highlights a general need for LDS technologies to minimize and simplify maintenance, for instance through the use of remote operating systems.

"Are the manufacturers going to be around in five years to support their product?"

RETURNS ON INVESTMENT

When asked to select the three applications for LDS they think currently offer the greatest potential for a return on investment, respondents provided a wide range of responses (figure 3).

The use that appears to offer the highest possibility is self-consumption for renewable energy.

Various grid management applications are also seen as offering potential, especially reducing consumption at periods where peak demand is forecast.

What is perhaps more important than any single application, however, is the fact that a wide number of potential revenue generation streams were chosen by respondents.

In practice, this should afford increased opportunities for project owners to maximize the return on investment for a given asset.

EVALUATION CRITERIA

By far the most important criteria utilities and developers currently use to evaluate LDS systems is capital cost, according to our survey (see figure 4).

This is understandable since availability of capital can be a limiting factor for energy storage projects.

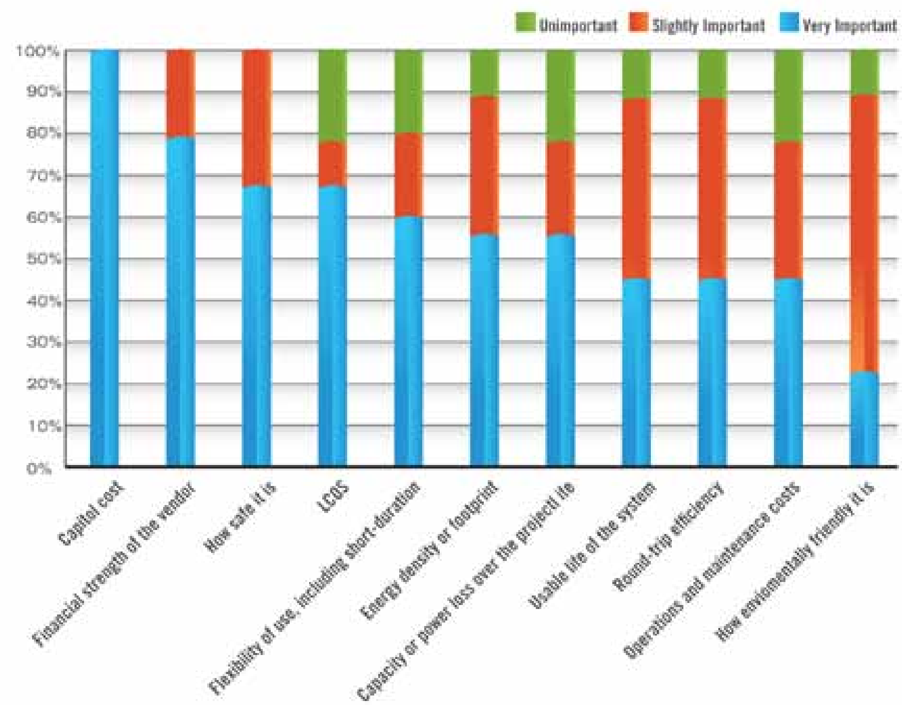

Figure 4: How important are these criteria in evaluating LDS?

Where possible, however, asset owners and developers often appreciate the need to view upfront cost as one variable within a wider economic model that incorporates lifetime costs and value streams.

Essentially, this can be achieved through a levelized cost of storage (LCOS) calculation that goes beyond the capital expense of a project and looks at lifetime value against operations and maintenance overhead.

LCOS is not a universally regarded measure, however. A minority of respondents were wary of the term, perhaps because it is seen as being difficult to verify through independent research.

Possibly linked to the number of LDS suppliers that are relatively young companies, many respondents also see the financial strength of the vendor as being very important.

"I like companies where the CEO has invested in the business."

IMPORTANCE OF VARIOUS CRITERIA

Other than capital cost, five other criteria emerged as important:

- How safe the technology is.
- Its LCOS in speci c applications.
- Its ability to be used exibly and to provide short-duration storage.
- Its energy density or footprint.
- That it doesn't lose capacity or power over the project's life.

TECHNOLOGIES BEING CONSIDERED FOR LDS

Other than batteries, and depending on the scale of the project, technologies being discussed by our respondents include thermal, cryogenic, liquid air and compressed air energy storage.

Beyond Four Hours

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Ideal requirements when evaluating the levelized cost of storage (LCOS) of electrical LDS

For electrical energy storage, however, battery technology is by far the most flexible option because it can be deployed across a wide range of capacities, locations, and applications.

Lithium-ion batteries are seen as having potential for uses at up to four hours or when cycled infrequently, as well as in combination with larger capacity technologies, in order to provide a broader range of service provision.

And although they can be built up for longer durations, the cost quickly becomes prohibitive.

Lead-acid batteries are still being considered for projects, especially large-scale, high-energy systems such as island microgrids, because capital costs and maintenance are low.

Other emerging battery technologies under consideration are saltwater and copper-zinc. But flow battery systems are undoubtedly the technology most would consider using for LDS deployments at the moment.

Flow batteries beat Li-ion on LCOS because the levelized cost depends heavily on the number of megawatt-hours involved, which rises in LDS.

A flow battery does not fade with frequent cycling and over time, so it offers a highly competitive price per MWh in four-hour-plus applications.

Flow batteries also have low operations and maintenance costs, with no need for replacement battery cells. At the same time they offer comparable response times to Li-ion, while having a round-trip efficiency that is only slightly lower.

Even within the many existing types of flow batteries, however, some are significantly better placed than others for LDS.

All-iron products, for example, have none of the scarce material costs associated with some other flow battery chemistries, so offer the potential for very signficant LDS cost reduction.

The all-iron chemistry also offers superior energy capacity, ease of installation and environmental benefits (figure 5).

CONCLUSION: TOWARDS A MORE FLEXIBLE USE OF STORAGE

There may be uncertainty over the role and nature of long-duration storage, but it is not for lack of consideration. Long duration storage is the best, most economic "hedge" against the inevitable shifts that will take place in the regulatory, legislative, and economic landscape due to its inherent exibility and low LCOS.

Our research clearly indicates many storage decision makers are aware of a rapidly growing need and business case for LDS and are keen to gain a better understanding of possible options for deployment.

As with all storage projects, cost remains a primary concern when selecting vendors and technologies. Sometimes this is wrapped up in LCOS, but as often as not, as one respondent put it: "capital cost is the limiting factor."

This does not mean lowest cost always wins, however. Smart storage purchasers will be aware that the winning strategy for storage involves being able to capture the greatest range of value streams for the lowest possible LCOS.

In this respect, the key for LDS may not in fact be duration, which is merely a technical feature, but exibility: to capture revenue streams, adapt to a range of locations, continue working over time and so on.

Flexibility will also be key for project developers and owners as energy storage moves beyond the currently well-defined use cases occupied by Li-ion and into new areas where a few extra hours of storage may be of financial benefit.

FOR COMMERCIAL/UTILITY ENERGY STORAGE APPLICATIONS

	Flywheels	Lead Acid Batteries	Li-ion Batteries	Trad. Flow Batteries	ESS Iron Flow Batteries
Cost	Good	Good	Medium	Medium	Good
Energy Density	Good	Poor	Good	Poor	Poor
Energy Capacity	Poor	Poor	Medium	Medium	Good
Installation	Poor	Poor	Medium	Medium	Good
Cyce Life	Good	Poor	Poor	Good	Good
Depth of Discharge	Medium	Poor	Good	Good	Good
O&M	Medium	Poor	Medium	Medium	Medium
Response	Good	Medium	Medium	Good	Good
Environment	Good	Poor	Poor	Medium	Good

Good Medium Poor

Figure 5: Comparison of different electrical storage technologies.

Herein lies a dilemma, because LDS applications are largely beyond the economic reach of the major battery players that serve the Li-ion sector. Thus we predict the following trends for the coming 12 months:

- An increasing mix-and-match approach to storage projects, perhaps combining Li-ion with other technologies that allow for greater application flexibility.
- Greater understanding of winning business models and the technologies most appropriate to them.
- An increasing number of utility-led pilot programs aimed at gaining experience with LDS.
- Growing interest in LDS in general. wn

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BY | ALEX BYRNE | SENIOR ENGINEER

The operation of wind turbines beyond their design life, presents both opportunities and risks for project stakeholders. The opportunity for added revenue through additional years of operation is easy to recognize; however, long-term availability, as well as decommissioning or repowering rates at a specific project, are difficult to predict.

Extending Wind Turbine Operating Life

Further, there are risks with running a project past its design life: the uncertain cost of additional inspections and monitoring required, supply chain vulnerability, availability of original equipment manufacturer (OEM) support, uncertain terms of future power purchase agreements (PPA) or interconnection agreements, and regulatory permits.

Because structural reliability decreases with operating time, when turbines are operated for more than 20 years, they will eventually reach a level of reliability below that intended by the certified design. Though it may be many years before this happens, continuing to operate, exposes the owners and other stakeholders to risks associated with the possibility of catastrophic failure, injury to people, property damage, environmental damage, and impacts to public relations. Most countries do not have any regulations governing extended operation of wind turbines, but such regulations may be put into place in the future. In the meantime, it is up to the owners and other stakeholders to decide how to manage project lifecycle decisions, weighing the potential benefits against increased risks.

This article focuses on the engineering discipline of structural reliability and operating life; however, the business aspects are equally important in the success of any life extension endeavor.

PURPOSE AND OBJECTIVE

The purpose of this article, is to provide readers with knowledge of the technical aspects of operating life of wind turbines, including explanations of the theory behind structural reliability, mechanical turbine loading, fatigue calculation methodology, and impacts of inflow conditions. Not included in this article is non-technical aspects of operating life extension; though important, they are outside the scope of this article. These topics include risks and impacts around contracts, environmental permits, and financial aspects of a project. This article is also not intended to be a comprehensive instructional document for assessing life, but rather intends to provide a strong technical basis so that the reader may leverage a technical understanding of lifetime topics when engaged in planning, oversight, strategic development, and other decision making around operating life.

Wind Turbines

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WIND TURBINE LIFE: THE ENGINEER'S PERSPECTIVE

Wind turbines are unique structures: the number and variability of fatigue cycles they experience in their lifetime is significantly greater than for most other engineered structures such as buildings or bridges. They operate in a highly variable and unpredictable environment, where the forces imposed on the structure by the wind change continuously, which is different than other rotating machinery, such as gas turbines, which experience predictable cyclic loads in a controlled environment.

At the same time, the consequence of failure for a wind turbine is quantitatively and qualitatively different than that for a structure that protects human life (such as an airplane or building), or a structure that protects the environment or provides a different value to society (such as an offshore oil/gas platform).

Lessons can be learned from these industries, as they have already faced the question of structural longevity, while the wind industry is still relatively young.

Unfortunately, there is little empirical data about how long wind turbines will survive in the field except for a small population of turbines of early vintage (pre-2000) that generally were not designed or operated in a similar manner to today's megawatt-scale turbines. Thus, experiences with these smaller vintage wind turbines cannot necessarily be applied. As more modern turbines are operated well past their design life, the wind industry will be able to validate and calibrate analytical approaches to calculating operating life. In the meantime, operating life assessments will be unavoidably uncertain.

For now, the best approach to mitigating the risk of catastrophic failure is to calculate the expected operating life, monitor the structural integrity through inspections, apply appropriate operational strategies, and eventually decommission or repower.

RELIABILITY DEFINITIONS

Structural reliability is defined according to International Standards Organization (ISO) 2394:1998, General Principles on Reliability for Structures [2] as the *"ability of a structure or structural element to fulfill the specified requirements, including the working life, for which it has been designed."* A target or design reliability level is the reliability level that the structure is designed to be at, or above, for the duration of its design life. This can be expressed as the inverse probability of failure: the lower the probability of failure, the more reliable the structure, and the higher the reliability level. A target reliability level is determined through consideration of various factors [2], including the consequences of failure (impacts to people, the environment, economic loss, and social impacts), balanced against the cost of measures that would reduce the risks of failure. Various industries have worked to establish target reliability levels that are acceptable to regulatory, financial, owner, and public stakeholders. These are often communicated in the form of standards and/or regulatory requirements, but can also be implied in design, siting, or operating requirements.

Structural design life is the number of operating years after which the attained structural reliability level is expected to drop below the target reliability level, given specified design conditions. Structural design life of wind turbines is stipulated by various wind turbine design standards as a minimum of 20 years [3]. Stated differently, if a wind turbine is designed to a reliability level expressed as annual probability of fatigue failure of five in ten thousand (5x10^{-4}), then the design lifetime is the year at which the expected annual probability of failure reaches 5x10^{-4} if the site conditions perfectly reflect the design conditions. [4]-[8].

Because no site will conform perfectly to the wind turbine class wind regime, it is useful to define the term structural site life, which can be used to represent the calculated number of years to reach the design structural reliability level under site conditions. In other words, the structural site life is the number of years a turbine can operate in site-specific wind conditions before the expected fatigue damage on the structural components exceeds the fatigue damage that would be expected in the design wind conditions over the design lifetime. This is illustrated in Figure 1.

Another way life can be considered is in terms of the number of years of operation for which it is economically attractive to continue to operate the turbine or project when considerations are made for (1) risks of continued operation and (2) project economics of extended operation compared to alternative options such as repowering. This period of operation is referred to as the economic life (or sometimes "useful life"). All factors impacting project costs and revenues must be considered including failure rates of nonstructural components, probability of failure of structural components, supply chain risks, and the risk of component obsolescence. The economic life may be significantly shorter than the structural site

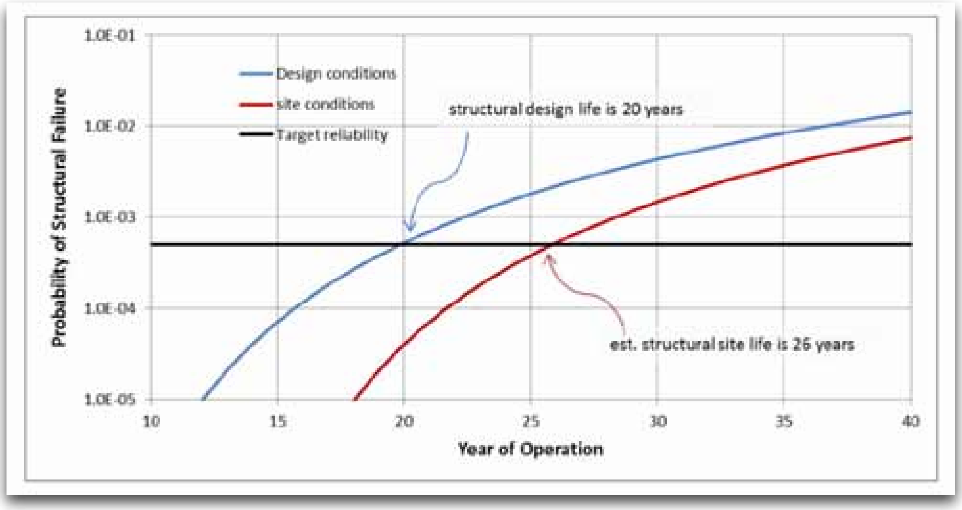

Figure 1 Probability of structural failure example demonstrating estimated structural site life relative to structural design life

life if operating costs increase sharply or if the cost of repowering drops significantly in the project lifetime.

Operating life extension refers to intentional actions taken to allow for safe continued operation beyond design life. This can be accomplished in conjunction with evaluation of the structural site life through a combination of the following approaches:

- Implement operational or controls modifications to reduce the structural loads
- Refurbish or replace structural components (may not be possible for all components)
- Implement risk-based inspections or instrumentation to monitor component condition and predict component failure. Follow up with repairs, replacements, or decommissioning depending on findings.

Design margin and site load margin refer to ratios of strength and load. **Design margin** is the ratio between the designed component strength and the load it was designed to withstand. **Site load margin** is the ratio of design load to site load. For fatigue loads, site load margin is typically calculated as the design damage equivalent load (DEL) derived from load cases provided in design standards - divided by the corresponding DEL imparted by the site conditions over 20 years, minus 1.

When turbines are sited conservatively, there is positive site load margin. For example, if there is an 8% site load margin on the main shaft in bending, this implies that the loads imparted by the site conditions are 8% lower than the design loads. As a simplification, it is normally acceptable to assume that site load margin and design margin are additive; thus, a 5% design margin and 8% site load margin means the main shaft is capable of resisting loads 13% greater than are expected at the site. The impact of margin on fatigue life is nonlinear and depends on the material fatigue strength characteristics.

In recent years, as the wind industry has looked for ways to cut the cost of energy, it has been observed that turbines have been sited less conservatively than in the past, and today site load margins are smaller on average. [9]

STRUCTURAL FAILURE

Structural failure is an event in which a structure can no longer resist the loads it experiences; in other words, it is the loss of load-carrying capability. Examples of structural failure are: a severely cracked or debonded blade, a cracked hub or mainframe casting, or a through-crack on a tower weld.

Structural failure can occur in two ways:

a. An instantaneous load exceeds the ultimate strength of the material, or
b. The cumulative cyclic fatigue loading over time exceeds the fatigue strength of the material.

Large instantaneous loads may be caused by events such as extreme gusts, severe wind direction change, or operational actions such as emergency shutdown concurrent with severe wind conditions. The environmental conditions giving rise to extreme loads events are component-specific and may arise due to operating or non-operating conditions. These instantaneous loads have a constant probability of occurrence for any period in a turbine's lifetime. Fatigue damage, on the other hand, accumulates over time and is driven by the quantity and magnitude of cyclic loading. Consider, for example, how a paperclip can be broken through a number of cycles of repeated bending.

As shown in in Figure 2, the probability of fatigue failure at any moment is dependent on the history of fatigue loading leading up to that time and increases with increased operating time.

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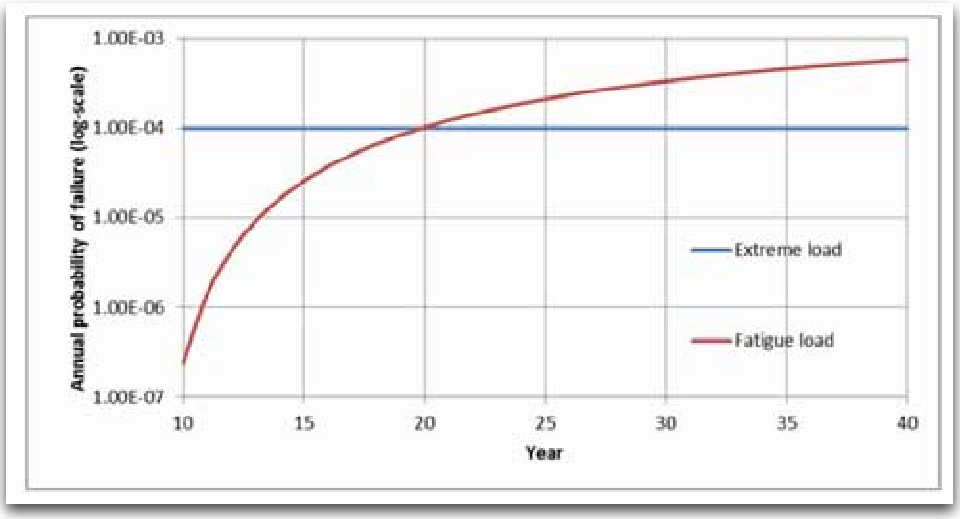

Figure 2 Annual probability of failure example demonstrating probability due to fatigue loading and due to extreme loading

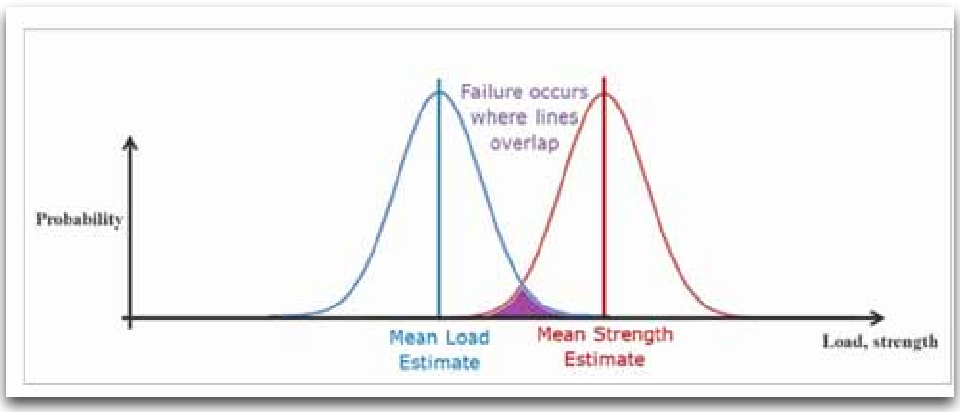

Figure 3 Illustration of probability distributions of load and strength

To minimize the chance that failures occur during the turbine design lifetime, there is safety margin engineered into all designs such that the average probability of structural failure within the design life is very small, or put differently, the target reliability level is high. In the limit-state design philosophy, which is applied to wind turbine designs, safety margin results from the application of safety factors to estimates of strength and estimates of loads. Safety factors have been developed based on an understanding of uncertainty in material strength, loads, manufacturing capabilities, and analysis methods such that the probability of failure within the design lifetime is acceptably low. The safety factors applied during the design phase are expected to match the realized safety level on average over a large population; any given individual turbine may realize a safety level above or below the design level. There is a probability distribution in both the strength and load such that any given component could be above or below average material strength or be subject to loads that may be above or below average (as illustrated in Figure 3). Use of safety factors reduces the possibility that a component will fail if it was made from material with below average strength and/or it experiences higher than expected loads.

DESIGN STANDARDS AND CERTIFICATION OVERVIEW

Onshore wind turbines are most commonly designed according to the International Electrotechnical Commission (IEC) standard 61400-1, "*Wind Turbines – Part 1: Design requirements*" (the *"IEC design standard"*) [3]. The stated purpose of the IEC design standard is *"to provide an appropriate level of protection against damage from all hazards during the planned lifetime."* The IEC design standards are intended to be used in conjunction with numerous other IEC and ISO standards, as well as ISO 2394, [2] and local building codes.

Wind turbines type certified according to a certification scheme such as IEC 61400-22 Guidelines are deemed to be mostly free from design defects and major engineering oversights; however, type certification does not provide a guarantee of structural integrity because wind conditions and operations are widely variable and manufacturing defects occasionally cause structural problems, particularly for blades. In blades, the achieved strength is highly dependent on both material properties and manufacturing processes.

Project certification or site specific design assessment is the process by which the project loads are verified to comply with the design conditions of a specific standard given the certified turbine model selected. As part of the project certification process, manufacturing, transportation, installation, and commissioning are surveyed or witnessed to some degree.

Wind turbines certified to a design standard are expected to be capable of withstanding extreme and fatigue loads that would be generated by the wind conditions prescribed for the wind turbine class. However, because of the complexities of commercial and technical design tradeoffs, e.g., "platform" product development, many components are designed to withstand higher loads than those generated by wind turbine class wind conditions, which implies an additional design margin above that achieved by application of the required safety factors for a given component.

The IEC design standard guidelines dictate that wind turbines be designed to at least a 20-year life; some are designed to 25 years.

TURBINE FATIGUE LOADS AND LOAD PATH

The structural design of a wind turbine involves designing for strength to resist all mechanical loads expected in a specified design environment, for a specified lifetime.

The sources of primary mechanical loads acting on a wind turbine include:

- Aerodynamic loads (drag and lift forces on blades; drag forces on nacelle and tower)
- Gravity loads (weight of tower, nacelle, and rotor)
- Inertial loads due to elastic flexing and motion of blades and tower
- Centrifugal and Coriolis loads due to rotation (on rotor)
- Gyroscopic loads (due to yawing)
- Electromechanical loads (generator torque)
- Seismic activity
- Hydrodynamic loads (due to waves and currents for offshore turbines)

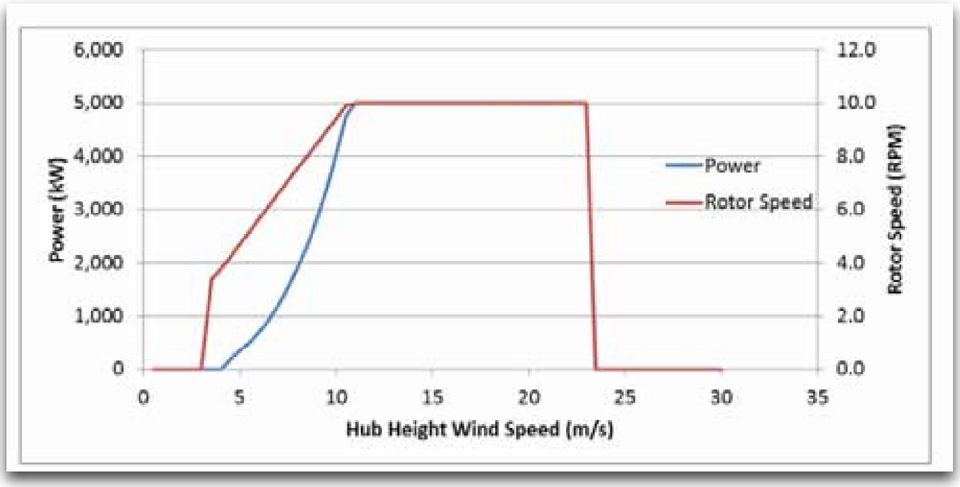

Figure 4 Example power and speed curve

Secondary loads include effects of lightning strikes, hail, ice, dust and rain.

As mentioned earlier, fatigue loads drive the structural life of wind turbines (if the extended lifetime is within certain bounds), therefore we focus on the two leading sources of fatigue loading: aerodynamic and gravity loads on the rotor, which are driven by the following conditions:

- Turbulent winds (leading to stochastic aerodynamic loads)
- Rotation of the rotor (leading to cyclic gravity loads)
- Wind shear (leading to cyclic aerodynamic loads)
- Off-axis wind (leading to cyclic aerodynamic loads)

Grid activity and control activity (such as emergency stops, grid loss events, etc.) can also drive high magnitude, low cycle loading events.

Below rated power, the rotational speed of a wind turbine is controlled to increase with wind speed; at rated power, the rotational speed is nominally constant ("rated speed"), as shown in Figure 4. Because the rotation of the rotor drives cyclic gravity loads on the blades, hub, and main shaft, the number of hours spent operating at different wind speeds directly affects the number of gravity-induced fatigue load cycles that the rotor will experience.

Other than gravity-induced loading due to rotor rotation, wind turbine fatigue loading in general is highly variable in frequency and magnitude because it is largely driven by the stochastic nature of turbulent wind. It is thus convenient to represent any stochastic load time-series as a single equivalent value such that it can be compared to other time series or manipulated arithmetically. Rainflow counting and DEL calculations are techniques used to quantify the impact of the combined periodic and stochastic loading of turbine structural components, as explained below.

RAINFLOW COUNTING AND MINER'S RULE

Fatigue strength curves such as the one shown in Figure 5 are the result of laboratory tests of material samples put under cyclic loading. These curves are material-specific. The negative inverse slope of the curve, often referred to as the 'Wöhler exponent', is designated by the

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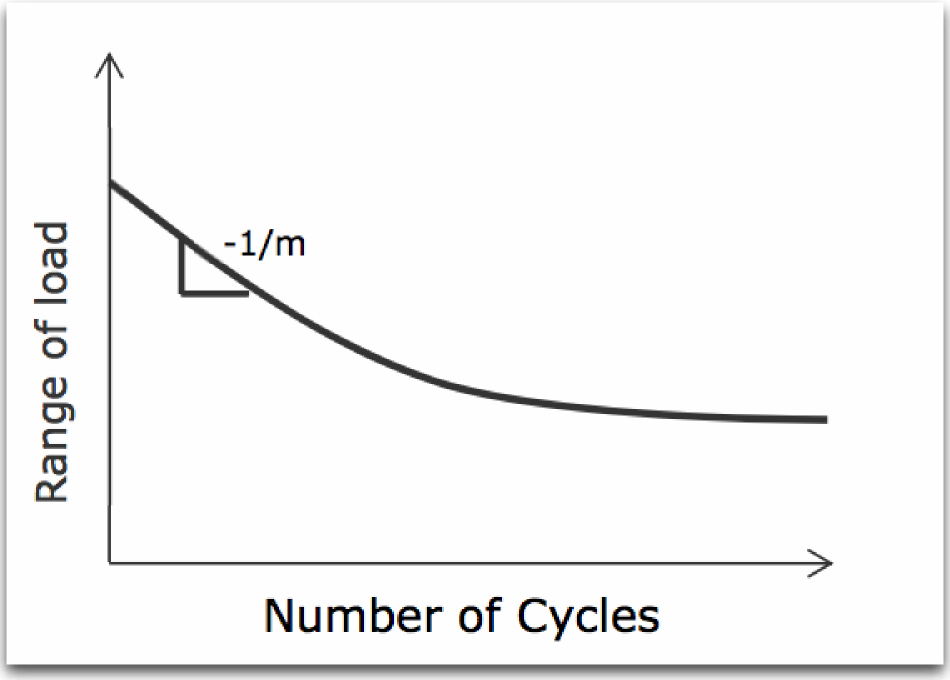

Figure 5 Example fatigue strength curve (S-N curve) (material-specific)

symbol m. Common values for m are 4 for welded steel structures and 9 or 10 for fiberglass composites.

"Miner's rule" is the mathematical equation used to sum fatigue damage from a number of random cycles at different load levels. Rainflow counting is used to translate a highly variable load time series into an equivalent number of cycles at specified amplitudes. Once rainflow counting is done, Miner's rule can be applied to calculate DEL range, abbreviated Req. In the below equation, Neq is the equivalent number of cycles (this is arbitrary but typically chosen to be 107 for a turbine lifetime), m is the Wöhler exponent, and ni is the number of expected lifetime cycles (over a given number of years) at load range Ri.

$$R_{eq} = \left[\frac{\sum (n_i R_i^m)}{N_{eq}} \right]^{(1/m)}$$

Rotating machinery, such as gears and bearings, experiences fatigue damage accumulation through the aggregate lifetime histogram of hours at a given load level. This is represented by calculating load durations (torque durations for gearboxes and bearings), sometimes referred to as a load duration distribution (LDD). The LDD together with information on rotational speed may then be used to derive DELs for gears and bearings.

The processes of calculating DELs are simplifications and contain inherent uncertainties, but fatigue damage accumulation would be challenging to predict without these simplifications. The process is outlined in Figure 6.

STRUCTURAL LOAD DRIVERS

The calculation of structural site life typically focuses on the survivability of structurally critical components. Structurally critical implies that local failure of a component would lead to rapid failure of major parts of the wind turbine. Foundations, towers, mainframes, main shafts, main bearing housings, gearbox housings, hubs, and blades are considered structurally critical components in a wind turbine.

Fatigue loading on the rotor is driven primarily by changes in aerodynamic lift and drag forces and gravity forces and secondarily by inertial and gyroscopic forces. In the context of operating life extension, one is interested in understanding what drives instantaneous changes in loads because constant loads do not contribute to fatigue damage.

Simplistically viewed, drag and lift forces increase or decrease with air density and wind speed if other variables (like blade angle of attack) are held constant.

The gravity fatigue loads on the blades, hub, and shaft are driven by the number of rotations of the rotor; as such they are not very sensitive to air density.

In an attempt to simplify the description of a complex inflow environment, it has become standard practice in the wind industry to summarize the factors driving loads with statistical parameters, shown in Table 1.

However, best practice is to use full distributions including correlations between parameters when performing any loads analysis, rather than to use high-level summary statistics.

OPERATING LIFE EXTENSION

I am of the opinion that it is often feasible to economically extend the operating life of a wind project beyond the structural design life if proper consideration is given to the following points:

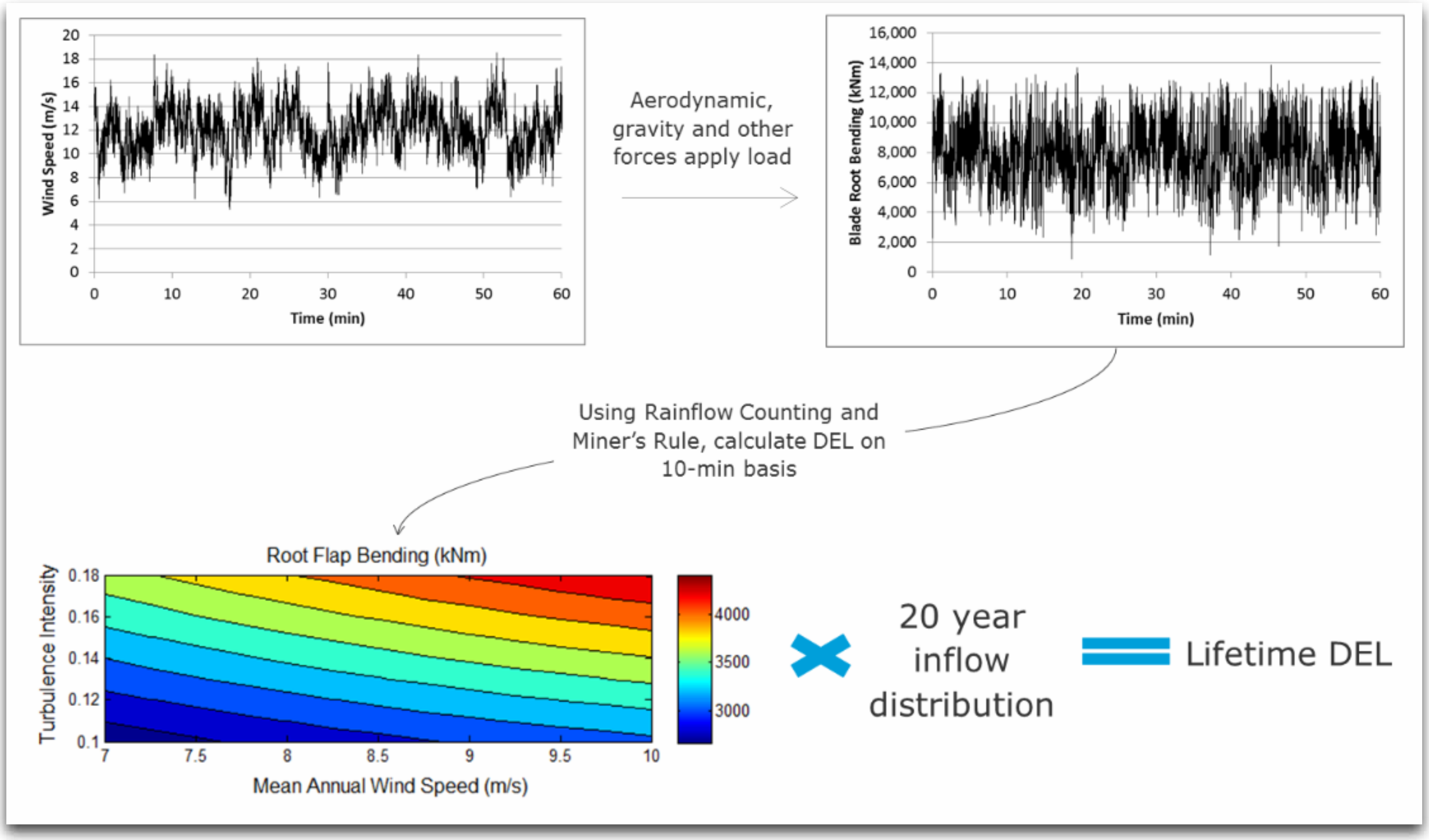

Figure 6 Flow chart for calculation of DELs

1. Structural: A site-specific loads analysis should be performed to assess the additional fatigue loading associated with extended operations relative to design strength for structural components and to inform structural inspections plans. [1]
2. Foundations: The wind turbine foundation design and construction should be reviewed to ensure the foundation has adequate strength for the planned additional years of operation and to identify monitoring and inspection requirements during the extended operations.
3. Inspections: An inspection plan should be developed to account for increased risk. The plan should include a targeted structural inspection campaign that includes inspections for early signs of structural failure (such as cracks) or weakening through deformation or corrosion. The results of the inspections can be used to update the calculated structural site life. [1]
4. Electrical Balance of Plant (EBoP): The EBoP design and condition should be reviewed to ensure the system is capable of meeting requirements for extended operations.
5. Non-structural: Most replaceable components' failure rates are expected to be constant with time or to follow a Weibull curve. We expect the failures to continue to follow the same curves in years 20-30 as they do in years 6-20 after an initial infant mortality period approximately covering years 1-5. Contingencies and plans should be in place if there are supply chain risks for a given turbine technology.

These steps should be taken early enough in the project life to allow for corrective measures that might need to be taken to achieve the desired operating life. The general steps are outlined in Figure 7.

OPERATIONAL ASSESSMENT

Operational assessments are an important part of an overall life extension strategy. They aim to provide an objective view of the operating and load exposure over their operational period, and to forecast the operational and load exposure going forward.

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Statistic	Impact on aerodynamic loads	Impact on gravity loads
Mean annual wind speed	Instantaneous wind speed fluctuations are of greater amplitude at higher wind speeds.[1] Therefore, higher mean wind speeds result in more hours spent in a high-fatigue load environment, and thus a greater fatigue load.	Higher mean wind speed results in more operating time at higher rotational speeds, and therefore an increased number of rotations experienced in a year.
Shape of annual wind speed distribution (Weibull k factor)	Higher shape factor for the same mean wind speed shifts the number of hours per year spent at higher wind speeds (higher loading) down to lower wind speeds (lower loading).	Shifting hours from high to low wind speeds or vice-versa has an impact on the number of gravity load cycles.
Mean annual turbulence intensity (TI) [2]	Drives the magnitude of random loading cycles on the blades and tower.	No impact
Mean annual upflow angle	Leads to cyclic aerodynamic loads as the airfoil orientation to the direction of the wind changes in a similar fashion as yaw error.[3]	No impact
Mean annual shear exponent	Leads to cyclic aerodynamic loads as each blade passes through a full rotor rotation.	No impact
Mean annual air density	First order effect is a linear scaling of aerodynamic forces and resulting fatigue cycles.	No impact

TABLE 1 - Drivers of aerodynamic and gravity fatigue loads
1. TI, calculated as the standard deviation of wind speed divided by the mean wind speed in a given 10-minute period, decreases or stabilizes with increasing wind speed, but the instantaneous fluctuations of the wind speed (which drive fatigue loads) increase with increasing wind speed.
2. TI for a given turbine location is calculated based on the ambient measured TI, calculated wake-added TI due to the presence of nearby turbines, and terrain complexity.
3. The impact of yaw error on fatigue loading in a site specific load analysis is not typically specific to the site.

These assessments comprise a review of the following aspects on a turbine-by-turbine basis:

- Energy production per turbine;
- Operating schemes, such as wind sector management, curtailment, derating;
- Availability history;
- Component failure history (if available including records from other wind turbines of the same type);
- Maintenance activity history;
- Fault and downtime history;
- Impact of any historical severe events, such as hurricanes and earthquakes.

In conjunction with an estimation of the inflow conditions, the operational assessment helps inform the calculation of the structural site life.

INFLOW ASSESSMENT AND STRUCTURAL RELIABILITY ASSESSMENT

There are many ways to calculate structural site life; when a stochastic process is involved, the process is called a structural reliability assessment. The simplified approach is described herein with additional discussion around accounting for uncertainty. Additional methods can be found in the standard on lifetime extension, including a detailed approach to be employed when detailed design information is available and a probabilistic approach which feeds into risk based inspections. The probabilistic approach yields a reliability level per year in addition to quantification of the structural site life. In order to estimate the structural site life, some understanding of the historical and expected future loading is required. This understanding can be developed from an assessment of the inflow conditions based on both pre-construction meteorological data as well as data from the operating period.

With this understanding, the site loading can be estimated and compared against the design loading. The loads can be estimated through aeroelastic simulations for estimating both site loading and design

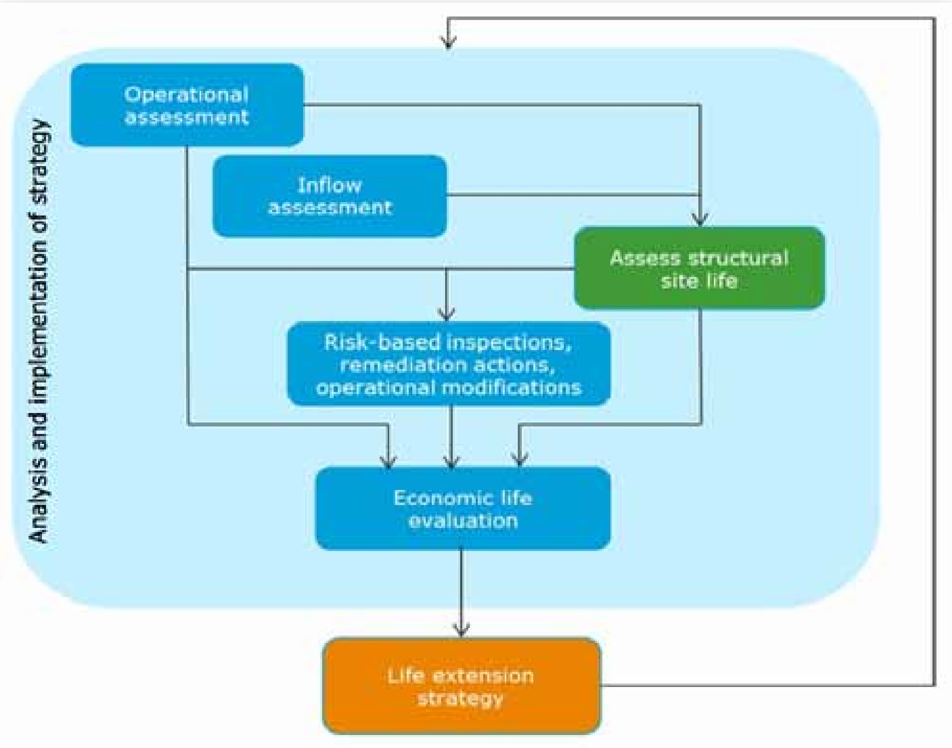

Fig 7 Flow chart demonstrating steps to extending operating life

loading through modeling site and design inflow and operating conditions.

The results can be translated into structural site life using the following equation: Structural site life = Structural design life * (1 + site load margin)m where site load margin = (design loads)/(site loads)-1

Propagation of uncertainty from any of the input variables (site load margin, or m) may be calculated using a Monte Carlo simulation, other stochastic methods, or can be calculated arithmetically. There are many sources of uncertainty, notably:

- Inflow condition estimation (measurement error, extrapolation and processing techniques, wake calculations)
- Fatigue assessment models, Miner's rule
- Material properties, fatigue test data have a lot of scatter
- Load simulation techniques
- Design margins, stress calculations

Support and access to information from the turbine OEM can help reduce uncertainty in load simulations, design margins, and stress levels for the component.

Uncertainty in a calculated structural life estimate is dramatically increased with a higher Wöhler exponent (m), so life assessments will typically be more uncertain for fiberglass components than for steel components.

Use of an aeroelastic model of the specific turbine model in question will reduce uncertainty; however, because the structural life assessment relies on relative loads (site load relative to the design load), a generic turbine model may be sufficiently accurate if it is of the same general architecture and control approach as the specific turbine model in question.

Regardless, uncertainties should be accounted for in the analysis.

This article primarily focuses on failure due to fatigue wind loads and fatigue gravity loads exceeding the turbine fatigue strength; however, there are other ways in which a wind turbine can fail which should be considered:

- Environmental events such as earthquakes, tornados, floods, and hurricanes: These types of risk can be ranked by geographic region and their commercial impacts can be mitigated through insurance.
- Loads due to extreme wind speed, inflow, or direction-change events: Some types of extreme events can be evaluated on a probabilistic level; this risk is best understood when many years of quality on-site wind data is available.
- Manufacturing or design defects: These types of risks can be mitigated by using certified machines, pursuing verification or certification (preferably involving the OEM) for any design modifications made during operation (such as uprating or adding aerodynamic devices), and by employing manufacturing surveillance. Furthermore, leveraging lessons learned from other turbines of the same type through user groups or updated maintenance manuals (if available) can reduce this risk.
- Poor maintenance practices, such as not rectifying leading edge erosion: This type of risk can be mitigated through regular audits of maintenance practices, benchmarking against industry best-practices, regular inspection of turbine condition, etc. Also in this case leveraging lessons learned from other turbines of the same type through user groups or updated maintenance manuals (if available) can reduce this risk.

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- Improper operations, such as ignoring sector-wise curtailment for load mitigation or using improper control settings: This type of risk can be mitigated through regular operating assessments, diligent record keeping, and third-party review of operational practices.

RISK BASED INSPECTIONS AND CONDITION MONITORING

As any analytical approach has uncertainty associated with it, an important part of safety operating past the design life involves inspecting and/or monitoring the wind turbines for early signs of failure.

The results can be used to inform remediation when damage is found and to calibrate and update the analysis results. If inspected at appropriate intervals or continuously monitored, failures can often be identified early enough to allow for a decision to repair, replace, or decommission. Certain types of condition monitoring systems may also provide early indication of damage or degradation.

An inspection philosophy can be prescriptive at set regular intervals or can be risk-based. Risk-based inspections (RBI) enable management of the risk level over the service life and enable cost efficient management of inspections and maintenance activity. The RBI approach takes into consideration the inspection philosophy (especially acceptance criteria), consequences of failure, calculated structural site life, and risk analysis to specify inspections in terms of:

- Where and what to inspect (which components, and which aspects of those components)
- How to inspect (visual versus non-destructive testing method, and extent of inspection)
- When to inspect (inspection frequency)
- Which turbines (all or a subset based on risk or a random selection)

PREPARING TO EXTEND LIFE

Early in the life of a project, a vision toward extension should be developed. Having information and high quality data about historical operations, component failures, wind regime, energy generation, and other data is an important part of developing high-confidence models to support life extension decisions and investments.

As the topic of operating life becomes more important to the wind industry, having the data to support evaluation of and decisions around life will increasingly be tied to real value as projects undergoing sale and acquisition will be evaluated on the availability and quality of such records.

SUMMARY

In general, it is possible to safely extend wind turbine operating life, but there are significant associated uncertainties and risks in doing so. Wind turbine structures are subject to fatigue loading and structural damage accumulates over time.

Because safety factors are included in the design, the probability of structural failure at the end of the design life is low on average but may be above or below this nominal level for any specific turbine and will continue to rise with continued operation.

It will be years before the wind industry has enough data on structural failures from currently operating projects to support highly accurate predictions of operating life for any specific site and wind turbine type. Steps for planning for an extended operating life include the following:

- Work with OEMs in the project development phase to gather design information and to understand expected site-specific risks and possible mitigation strategies associated with an extended operating life
- Design foundations and electrical balance of plant for extended life
- Understand risk appetite of project stakeholders
- Record and maintain high quality operating and met data throughout the entire operating period of a project, including records of hardware and software modifications made to the turbines
- Identify and analyze risks associated with extended operations by:
  - Performing operational assessment
  - Evaluating site inflow data
  - Performing operating life assessment
  - Updating structural site life estimate with risk based inspection results
- Develop strategy and plan for extended operations in the following areas:
  - Operations and maintenance strategy including inspections
  - Supply chain
  - Health, safety, and environment
- Perform updated risk analyses during the project operation using data and experience gained on the project and the wind industry in general. wn

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- Ed

The rapid pace of technological change and product development is a global trend that affects entire economies. We may have access to more information than ever before, but is this information readily understandable? Does it give us insight into the fundamental issues? Is it precise and based on technical clarity?

QUESTION ONE

What is an E-house?

ANSWER ONE

An Electrical House, more commonly referred to as an E-House, is a metal pre-fabricated power distribution substation. These electrical buildings are designed, engineered and manufactured at a company's facility and deployed to site as a fully assembled and integrated unit. Typically, an E-House would be equipped with medium voltage switchgear, low voltage switchgear, instrumentation and auxiliary equipment.

QUESTION TWO

Can a mechanically constructed E-House be economically competitive when compared to a brick and mortar structure?

ANSWER TWO

Absolutely. There are several major cost advantages offered by selecting a mechanically constructed or pre-fabricated E-House over a brick and mortar structure.

The first, and most obvious of these, is that an E-House offers a fast and reliable power solution without the need for establishing of a complex civil infrastructure. This translates into significant cost savings in terms of planning and managing civil works, and is particularly relevant in remote areas where the cost of civil and infrastructure construction can be high.

The next, and probably most important advantage, is that when dealing with an OEM that offers a comprehensive E-House package you will only have to deal with a single supplier. This will free up significant time during the project and allow for a seamless approach at all stages from design through to fabrication, inspection, testing and pre-commissioning; with all activities being undertaken at a single location. This will also allow for a reduction in the engineer's and/or consultant's team when managing the project, resulting in greater overall productivity with associated cost savings.

Another area which offers a cost advantage is the time saving as a result of all disciplines being combined when engineering and producing the E-House. In the case of a brick and mortar substation, once the structure has been completed individual elements which would probably have been made up off-site then have to be integrated into the building. This is a complex undertaking, often involving numerous sub-contractors, and is open to human error.

In the case of an E-House, this integration is carefully co-ordinated at the OEM facility and any teething problems can be immediately addressed ensuring that the final power distribution solution is delivered as a plug-and-play to site. Essentially, the construction of an E-House as a single source OEM supply option removes all the

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difficulties associated with managing multi-disciplinary contractors on site.

Another advantage which is particularly important in regions with high rainfall is that productive construction time is not lost due to poor weather conditions.

QUESTION THREE

What are the advantages of a mechanical E-House when compared to a brick and mortar structure?

ANSWER THREE

Among the major advantages of an E-House is that the electrical power solution is self-contained. This modular type of design allows optimum flexibility while reducing the overall footprint of the structure. Optimal use of space factors into most sites today and an E-House solution allows the use of the available space to be maximised.

Not only is easy on-site installation a reality with an E-House, it is also simple to change the location of the E-House without the need for additional civil infrastructure. This allows the E-House to be relocated as an operation develops and the main substation needs to move to a different working area.

In addition, the internal configuration of the E-House can be easily upgraded when necessary. In applications where required, multi E-Houses can be used, again leveraging on the flexibility that this option provides.

Information provided by Zest WEG Group

An E-House is also a perfect interim solution where electrical power needs to be provided prior to the balance of the operational infrastructure.

The E-House is a scalable solution which minimises project lead times and reduces on-site construction requirements. wn

IN MY OPINION : MAX CLARKE

Why should I join the SAIEE ?

This question is often asked of Institute members when groups of electrical engineers are meeting or socialising in their daily activities. Sometimes it is put differently ... "What am I getting out of my membership of the SAIEE?" is occasionally asked by a member when he/she receives their annual subscription statement! Some would argue that at the present time given the current "lethargy" in industrial activity in general, these are perfectly justifiable questions. But are they ?

BY | MAX CLARKE | FSAIEE

Consider for a moment that more than 100 years ago when the original group of 71 people met to inaugurate the SAIEE, their objective was "To promote the general advancement of electrical science... and, to hold meetings for reading or discussing communications, works or treatises bearing on electrical science...."

Implicit in these words is that fact that "getting (something) out of their membership" was what would follow after "promoting the general advancement of electrical science" , or "....discussing communications, works or treatises.....etc."

One is tempted to argue that the miracle of modern communications has rendered "getting together" an obsolete and unnecessary activity. And anyway, does "getting together" imply membership of one or other "organisation" as a pre-requisite for discussing technical or professional matters with colleagues or friends?

The advancement of the science and the application of electrical engineering takes place at many levels, from the laboratory to the project site.

A break-through in a lab remains a scientific curiosity for the most part, until it is applied to one or other real-life situation. And that application will surely reveal needs or quirks that vary from one situation to another.

How best to transfer the knowledge of any such development? A written treatise published in a professional journal? An oral presentation to a group of professional colleagues? An announcement on Facebook/LinkedIn/twitter? Maybe a little of all of these?

In the end, a dynamic, fully functional organisation will provide most of these needs – and many others - and create the environment for "promoting the advancement of the "electrical science". Reason enough to be an active member of the SAIEE.

Equally, it is a given that ....." the more you put in, the more you get out" of life. The "electrical science" is no different. No one can grow to their full potential unless they are "putting back" into any profession.

The Institution provides the gateway to do just that, whether it is representing the profession on statutory bodies, carrying out the sometimes mundane duties of serving on committees or function-related work-groups, or encouraging others in the "promotion of the science". There are needs and opportunities galore. The level of activity and the concomitant benefits that will accrue to the individual and "the science" are there for the taking.

In my opinion you owe it to yourself, your colleagues and the profession to put something back. I urge you to play your part to the fullest possible extent that your circumstances allow.

Your rewards will surely follow. wn

January | Movers, shakers and history-makers

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

1 JANUARY

1908 For the first time a ball was dropped in New York City's Times Square to signify the start of the New Year at midnight.

2 JANUARY

1818 The British Institution of Civil Engineers was founded.

3 JANUARY

1967 Dr Harry Thomason was awarded a patent for an apparatus that used solar energy to cool and heat a house.

4 JANUARY

1902 The French Panama Canal Company offered to sell its rights to build a canal to the US for $40 million.

5 JANUARY

1959 Buddy Holly released his last single "It Doesn't Matter"; he was killed in a plane crash 29 days later.

6 JANUARY

1925 George Washington Carver (an agronomist) was granted a patent for cosmetics (such as face powders and creams) made of plant products. These were not a commercial success as he had no formulae for it.

7 JANUARY

1991 Birthday of Caster Semenya, South African sprinter.

8 JANUARY

1964 USA President Lyndon B. Johnson declared a "War on Poverty" in the US. During his speech, he stated *"Our aim is not only to relieve the symptom of poverty, but to cure it and, above all, to prevent it".*

9 JANUARY

2007 Apple introduced the iPhone at the MacWorld Expo. The phone wasn't available for sale until June 29th, prompting one of the most heavily anticipated sales launches in the history of technology.

10 JANUARY

1893 Thomas Laine patented the electric gas lighter.

11 JANUARY

1955 Lloyd Conover patented the antibiotic tetracycline that is created with reducing the number of deaths from cholera.

12 JANUARY

1967 Dr. James Bedford, a University of California psychology professor, became the first person to be cryonically preserved with intent of future resuscitation. His remains are still preserved at the Alcor Life Extension Foundation.

13 JANUARY

1954 Birthday of Trevor Rabin, South African-American musician. He began playing guitar at the age of 12. In 1972 he formed the band Rabbit which became one of the most successful rock acts ever to emerge from South Africa.

14 JANUARY

1950 The first prototype of the MiG-17 makes its maiden flight. It's a high-subsonic fighter aircraft that was produced in the USSR from 1952 and operated by numerous air forces, including SA, in many variants.

15 JANUARY

2001 Wikipedia, a free Wiki content encyclopaedia, went online. Door-to-door encyclopaedia salespeople mourned while bookshelves everywhere suddenly had more room for other books. "Wiki" is a Hawaiian word meaning "quick".

16 JANUARY

2006 Ellen Johnson Sirleaf was sworn in as Liberia's new president, the first female elected head of state.

17 JANUARY

1984 The US Supreme Court ruled 5-4 that the private use of home video cassette recorders (VCR) to tape TV programs for later viewing did not violate federal copyright laws. This ruling opened the floodgate for VCR sales, and changed the landscape of television watching forever.

18 JANUARY

1911 Eugene B. Ely flew his Curtiss pusher aeroplane and landed on the deck of the armoured cruiser USS Pennsylvania stationed in San Francisco harbour. This was the first time an aircraft landed on a ship. This flight was also the first where the tailhook system, designed and built by circus performer and aviator Hugh Robinson, was used.

19 JANUARY

1978 The last Volkswagen Beetle made in Germany left VW's plant in Emden. Beetle production in Latin America continued until 2003.

20 JANUARY

1999 The Happy99 worm first appeared. It invisibly attached itself to emails, displayed fireworks to hide the changes being made, and wished the user a happy New Year. It was the first of a wave of malware that struck Microsoft Windows.

21 JANUARY

1939 One of the most well-known songs of the 20th century, "Over the Rainbow', was copyrighted. It is number one on the "Songs of the Century" list compiled by the US Recording Industry Association.

22 JANUARY

1970 The Boeing 747, the world's first "jumbo jet", entered commercial service for launch customer Pan American Airways.

23 JANUARY

2017 Today is Handwriting Day and you are encouraged to put pen to paper, and to practice your handwriting. The hand-written letter, note or document is fast becoming a thing of the past, the art of elegant (or even legible) handwriting may well be under threat.

24 JANUARY

1899 Humphrey O'Sullivan patented the rubber heel for shoes. He worked in a print shop where standing on the shop floor all day resulted in sore feet. To ease his aching feet, he started to stand on a small rubber mat, which acted as a makeshift cushion. His fellow employees kept "borrowing" the mat, so Humphrey cut out two pieces of the mat the size of his heels and nailed them to his shoes. The results pleased and astonished him. Soon, O'Sullivan was making full-fledged rubber heels, equipped with hidden washers to hold the nails.

January continues....

continues from page 65

25 JANUARY

1947 Thomas Goldsmith Jr. filed a patent for a "Cathode Ray Tube Amusement Device", the first ever electronic game.

26 JANUARY

1983 The Lotus Development Corporation released Lotus 1-2-3 for IBM computers. While not the first spreadsheet program, Lotus was able to develop 1-2-3 because the creators of VisiCalc, the first spreadsheet, did not patent their software.

27 JANUARY

1888 The National Geographic Society formed in Washington, D.C., USA. It is one of the largest non-profit scientific and educational institutions in the world.

28 JANUARY

1813 Jane Austen's Pride and Prejudice was published, for the first time, in the United Kingdom.

29 JANUARY

1991 A summit meeting between the ANC and IFP was held in Durban. Mandela met Chief Mangosuthu Buthelezi at the Royal Hotel in Durban and agreed to promote peace. This was the first time that Mandela and Buthelezi had met in 28 years.

30 JANUARY

2007 Six years after the launch of Windows XP, the infamous operating system, Windows Vista, was released to an unsuspecting public. For various reasons, the launch of Vista was marred by numerous incompatibility, stability, and otherwise onerous problems.

31 JANUARY

1983 The bestselling album of all time, Michael Jackson's "Thriller", was copyrighted.