NSX & NSXm Moulded Circuit Breakers
New integrated earth leakage protection technology for circuit breaker ranges

Save 40% installation time

Connect to Schneider Electric’s EcoStruxure Power architecture

Trip alarm, pre-alarms for proactive operational and energy efficiency

www.se.com/za

Electric Power and Energy:
- Renewable Energy • Generation •
- Transmission & Distribution • Application •
Reinhausen South Africa Now Offering
ON-SITE HIGH VOLTAGE TESTING
in South Africa and Neighboring Countries

HIGHVOLT Mobile Test System for
Power Transformers

CAPABILITIES

- AC induced voltage test with partial discharge measurement (noise level < 20 pC)
- AC applied voltage test up to 300 kV
- DC applied voltage test up to 800 kV (positive or negative polarity)
- No-load loss and current measurement
- Load loss and measurement of impedance voltage
- Temperature-rise test

BENEFITS

- Set up on-site within hours
- Reduce exposure and transport time
- No oil handling required
- Cost efficient

Reinhausen South Africa (Pty) Ltd
No. 20 Fourth Street, Booyens Reserve
2091, Johannesburg, South Africa
Tel: +27 11 835 2077/8
Email: support@za.reinhausen.com
www.reinhausen.com
New integrated earth leakage protection technology

Schneider Electric has announced the introduction of integrated earth leakage protection for its compact NSX & NSXm moulded circuit breaker ranges. The award-winning compact NSX moulded case circuit breaker range and the new, smaller compact NSXm range, now both feature integrated earth leakage protection, Micrologic Vigi (see page 4). Contact Prisca Mashanda, Schneider Electric, Tel 011 046-1900, prisca.mashanda@se.com.
Save up to 50% of your time when testing circuit breakers

As an application engineer I know how time consuming it is to change the wiring setup several times between the measurements. Therefore I helped to develop a solution, which combines a timing and travel analyzer, a digital low-resistance ohmmeter and a coil and motor supply in one device. We’ve cut down the wiring effort to a minimum, which greatly reduces the testing time and probability of measuring errors. This pays off with every CB you test.

www.omicronenergy.com/breaker

Alexander Herrera
Application Engineer

Alectrix (Pty) Ltd, South Africa
info@alectrix.co.za
www.alectrix.co.za
To readers, customers, suppliers, staff and other stakeholders of EE Publishers

It is with some sadness that we must advise that, after more than 25 years of business, EE Publishers will be closing at the end of November 2019.

The state of both the economy and the publishing sector in South Africa have impacted the company negatively as customers cut back on advertising and marketing activities.

Our primary revenue, namely advertising and marketing spend, is no longer adequate to ensure a sustainable traditional publishing business.

The service of the SA Post Office is unreliable, and its prices continue to spiral upwards and the cost of door-to-door magazine deliveries by courier is prohibitive.

In the meantime, readership preferences continue to shift away from print media towards electronic and social media.

However electronic media advertising spend in South Africa is being significantly eroded by the global social media majors, and this is shifting local electronic media advertising spend offshore.

It is however heartening for us to remember past achievements – from the initial business as the Elektron Partnership started by Jack Yelland, which brought the SAIEE magazine Elektron to profitability and growth – to the merging of the Elektron business with that of Energize magazine to form EE Publishers.

In due course we acquired further titles, Vector and PositionIT, and the establishment of EngineerIT magazine to replace Elektron magazine, which reverted to the SAIEE.

Highlights over the past 25 years included the winning of numerous Specialist Press Association Pica Awards for publishing excellence, and the close relationships established with numerous professional institutes and industry associations across the sectors served by EE Publishers.

We also ventured into staging major conferences and exhibitions, often partnering with relevant industry bodies – events such as Switchgear, Drives & Control; Intelligent Building Automation; GIISA Ukubuzana; SA Surveying + Geomatics Indaba; Geomatics Indaba; SA GeoTech; SA Energy Storage; and ICT Infrastructure.

This was supplemented with the staging of numerous public seminars and debates on topical issues of public interest across the sectors served by EE Publishers, the most notable of which were the series of five energy and ICT seminars hosted in partnership with Nedbank in 2019.

Our annual industry leadership and customer breakfasts were legendary, and the highlight of many peoples’ event calendars. Guest speakers included Judge Albie Sachs, Adv. Vusi Pikoli, Prof. Jonathan Jansen, Bobby Godsell, JP Landman, Michael Power, Ferial Haffajee, Prof. Anton Harber, Mark Heywood, Dr. Harry Selfel, Martin Welz and Nik Rabinowitz.

I believe the staff of EE Publishers can hold their heads high and be proud of what they have achieved over the years in service of our readers, customers, business associates, suppliers, professional institutes and industry associations, across the engineering and geomatics sectors of South Africa and the region.

A special thanks to the editors, writers, sales, production and administration staff for each of the four publications, EngineerIT, Energize, Vector and PositionIT, and our events management staff, for their dedicated service and the sterling work over many years.

I would like to single out the leadership roles played by recent editors of Energize magazine, namely Mike Rycroft and Roger Lilley, together with the associated editorial, sales, production, events and administration staff.

We take this opportunity to thank the many stakeholders of EE Publishers, including readers, customers, suppliers, professional institutes, industry associations and especially the staff for the wonderful journey we have had over the last 25 years.

It has been a pleasure and an honour to be part of, and to serve, the energy, electricity, measurement, instrumentation, automation, lighting, ICT and geomatics sectors of South and Southern Africa.

Chris Yelland and Irene Blythe

What is Energize?

Energize – the independent power and energy journal of Southern Africa – is a business-to-business journal, published by EE Publishers, eleven times per annum, serving the electrical power and energy sectors of Southern Africa.

Mission statement

Energize strives to keep readers abreast of the latest technologies, developments, applications and news in the field of electrical power and energy, by the publication of original, relevant, high quality articles, by expert authors. Energize provides a forum of communication for the electrical power and energy sectors of Southern Africa.
New integrated earth leakage protection technology

Schneider Electric has announced the introduction of integrated earth leakage protection for its compact NSX & NSXm moulded circuit breaker ranges. The award-winning compact NSX moulded case circuit breaker range and the new, smaller compact NSXm range, now both feature integrated earth leakage protection, Micrologic Vigi. This is a technology that monitors the flow of current and sends pre-alarms in the event of earth leakage, interrupting the circuit instantly, should it detect any organic disruptions, therefore effectively preventing the danger of electric shocks.

This innovation means that during the process of installing circuit breakers, panel builders and contractors are no longer required to install an additional earth leakage module, which can lead to savings of up to 40% in installation time. Because the ranges have integrated earth leakage protection, the same frame size as a standard breaker, they are designed to conveniently fit in the same row.

EcoStruxure Power connectivity

The ranges are part of the Connected Products portfolio of the Schneider Electric IoT enabled architecture, EcoStruxure Power, an open, interoperable, IoT-enabled system architecture and platform. It delivers enhanced value around safety, reliability, efficiency, sustainability, and connectivity for its customers. EcoStruxure leverages advancements in IoT, mobility, sensing, cloud, analytics, and cybersecurity to deliver innovation at every level. This includes connected products, edge control, and apps, analytics & services. EcoStruxure has been deployed in over 480 000 sites, with the support of over 20 000 system integrators and developers, connecting over 1,6-million assets under management through more than 40 digital services.

Reliability that fits

Designed with high-breaking capacities for all standard and specific applications, and with an operating current up to 630 A, the Compact NSX circuit breaker range features integrated earth leakage protection and offers local and remote communication with trip alarm and pre-alarms for proactive operational and energy efficiency.

The range provides corrective, preventative and predictive maintenance and energy management to enable potential savings, and ensure customer installations can be optimised, in terms of performance and protection.

Efficiency that clicks

As the newcomer to the range, for applications up to 160 A, the Compact NSXm range is designed for low-voltage panel boards and control panels. As the smallest frame size in the Compact NSX range, and similarly featuring integrated earth leakage protection, it is an ideal space-saving solution for installations. This efficient solution offers a flexible installation, thanks to a built-in DIN rail and plate mount capability, while field-installable options such as rotary handles and one-click auxiliaries make it easy to configure the circuit breaker to the user’s specific needs. The Compact NSXm range also features EverLink creep-compensating technology. This patented technology ensures a lasting connection by mitigating the loosening effects of heat cycling or vibration.

Increased efficiency

There is more pressure than ever for panel builders and contractors to come up with time and cost saving solutions during the process of efficient mounting, installing and cabling of switchboards for their customers. Schneider Electric’s NSX and NSXm integrated earth leakage protection technology ensures 40% saving on installation time.

Contact Prisca Mashanda,
Schneider Electric, Tel 011 046-1900,
prisca.mashanda@se.com
As the population increases, urbanisation intensifies, and climate change concerns heighten, the clamour for clean and decentralised electric power generation will increase. In that effort, distributed energy resources and off-grid power generation will play a key role.

**Powering the African labour market**

On-site, off-grid electricity generation can put the dream of affordable, safe, clean and reliable power within reach for every African. On one hand, it presents a massive commercial opportunity for African utilities to reach millions of people who live in dense, yet untapped, communities without a prohibitive financial outlay. On the other hand, the production of off-grid components, such as solar-based products, can create employment for hundreds of thousands on the continent. Job creation and income generation can further support sustained progress in electricity access and uptake, enhancing firms’ and households’ ability to pay. This will generate financial benefits for utilities and make electricity expansion economically viable, further encouraging investment and higher utilisation.

**New possibilities**

Rooftop solar photovoltaic (PV) systems, small wind farms, microgrids and battery energy storage will also allow consumers to generate their own power as well as sell it back to the utility, giving rise to new and competitive business models which will further optimise the cost of electricity. It will also lead to the development of more renewable energy technologies and associated industries such as electric vehicles, greatly reducing emissions of harmful carbon-based and other toxins.

**Solar PV installation on Robben Island.**

The good news is that integrating solar PV and wind plants into the existing electric networks is already cheaper than it was ten years ago, with costs predicted to drop even further in the foreseeable future. Battery costs are already plummeting. These developments provide opportunities to produce and store more renewable energy and expand its usage. Such distributed energy resources can be integrated with a wide range of diverse conventional electricity resources, enabling an uninterrupted, efficient and clean supply of power.

According to a statement made in August 2018 by Jeff Radebe, Minister of Energy at the time, the government aims to produce 27.6 GW of electricity using renewable resources (solar, wind, and hydro) by 2030 resulting in the creation of hundreds of thousands of new jobs. Technological progress underpinning off-grid electricity systems can provide enough electrical capacity for productive higher-tier uses at a significantly lower cost [1].

**Transition to clean energy generation**

The ABB microgrid solutions with battery energy storage systems are already ensuring stable and sustainable power, harnessing solar energy, and serving as a global model for the clean-energy future at the World Heritage Site Robben Island.

For microgrid solutions with battery energy storage systems, ABB’s energy management system, the ABB Ability e-mesh, monitors and controls system performance and helps to improve energy efficiency, fault identification and predictive maintenance through accurate demand planning and generation forecasting.

The solution covers the whole distributed energy ecosystem end-to-end, ensuring a safe and reliable supply of power. Although South Africa envisions a green economy wherein everyone has access to safe electricity, it needs to take a much bigger step towards more rapid integration of renewables into the power grid. As more and more people join the labour-force and climate change concerns worsen, the country must be more proactive in the rollout of smart power technologies which will help it provide a better standard of living to all its people.


Contact Thembisile Dzonzi ABB, Tel 010 202-5841, thembisile.dzonzi@za.abb.com ✤

---

**South Africa should open the door wider for renewables**

by Maxine Ghavi, ABB

South Africa’s advanced industrial and financial sectors, together with its abundant natural resources, have contributed in making it the second largest economy in Africa. But to bring power to the remotest corners of the country, to maintain its economic growth momentum and to reduce its carbon footprint, it must accelerate the adoption of efficient, economic, sustainable and eco-friendly modes of power generation.
The importance of gas as an energy source

South Africans seem to be convinced that the best form of energy is electricity. But this is not always true. Natural gas is a clean-burning source of energy which is ideal for many industrial processes. In the latest iteration of the country’s energy plan, the Integrated Resource Plan (IRP2019), gas is predicted to provide 8% of South Africa’s primary energy. It is time for gas to take its rightful place in the energy mix.

Gas is a clean and flexible fuel. It is ideally suited to replacing coal, liquid fuel and electricity in heating applications ranging from industrial heating and boilers to residential heating and cooking. A large number of industrial plants are well suited for own gas-powered generation to provide both heat and power.

Gas powered combined heat and power (CHP) applications become really attractive when the exhaust and engine waste heat is used to displace other energy sources such as electrical heating, steam, hot water and direct heating.

Utility power generation worldwide is typically 30% efficient. For the best CHP applications such as electricity and steam from a plant operating at full load, nearly 90% of the input energy is effectively utilised.

The carbon footprint of CHP is less than half of Eskom’s utility electricity. CHP may be combined with solar photo voltaic (PV) generation to lower carbon footprint even further. Gas-fired CHP also eliminates the 1,3 t of water required per kWh and particulates associated with coal fired utility generation.

A gas economy will contribute substantially to meeting South Africa’s carbon reduction commitments.

The IRP2019 defines the generation capacity against which generation licences can be granted. This allocation is per year for each technology. A 500 MW allocation is included per year for private generation, which includes solar, wind and power generation.

This removes a key barrier to private generation allowing clean, efficient generation to take its place in South Africa; all at no cost to the taxpayer.

The IRP2019 includes two gas fuelled power plants with 1000 MW coming on grid in 2024 and 2000 MW in 2027. This generation is typically aero-derivative gas turbines, utilising the same turbines which are used on aircraft. These turbines can be started and be on load within 10 minutes; the ideal technology to provide top-up power for morning and evening peaks and compliment wind and solar.

Kickstarting gas

The Mozambique pipeline delivers 180-million GJ of natural gas to South Africa each year from the Temane gas field in southern Mozambique. The majority of this gas is used for Sasol’s as to Liquids process with 37-million GJ distributed to industrial, commercial and residential customers by Sasol Gas, Springs Light and Egoli Gas. In addition, a further 25-million GJ of methane rich gas is distributed to industrial customers by Sasol Gas.

The existing gas supplies to South Africa are fully utilised and the Temane gas field is tapering off. Additional gas supplies are required if the IPR2019 generation allocations are to be realised.

Liquified natural gas (LNG) provides the solution for transporting natural gas to areas where pipeline gas is not available. Natural gas is cooled to -160°C where it becomes liquid, enabling it to be transported by LNG carrier. LNG currently accounts for approximately 10% of world energy demand.

Significant regional LNG supplies are being developed in northern Mozambique with first shipments scheduled for 2023/2024. The IRP2019 gas demand is easily supported by LNG if the infrastructure on the South African side is in place.

A floating storage and regasification unit (FSRU) allows the local infrastructure to be implemented within the IRP2019 timeframe. The FSRU comprises a liquefied natural gas (LNG) carrier with on-board regasification. A single FSRU is capable of delivering gas volumes comparable to the existing Mozambique gas pipeline.

In a South African scenario, the FSRU would be permanently moored and linked to the shore-based gas distribution network. The on-board LNG storage facility would be replenished by conventional LNG carriers as required.

The key advantage of a FSRU is the rapid deployment and conversion of capital cost to a tolling cost. LNG is a flexible fuel as it can be regasified (RLNG) and delivered to the pipeline network to suit demand or distributed as LNG by road or rail.

The FSRU allows consumers to be added to the existing gas distribution network and will promote gas network expansion as it is driven by demand.

This is most easily implemented in Richards Bay where there is existing port infrastructure. RLNG delivered to...
existing gas distribution will support local demand, freeing capacity in the Lily gas line and allowing the gas flow in the Lily gas line to be reversed to deliver RLNG to the highveld. As gas demand increases it becomes financially feasible to replace the FSRU with permanent shore-based storage and regasification.

Coega and Saldanha are also favoured for LNG import but require more significant marine works to accommodate delivery from a standard LNG tanker. The opportunity exists to serve these sites with smaller shuttle tankers operating from Richards Bay. Technical solutions exist to supply the gas required to implement the IRP2019 gas generation allocations within a relatively short time frame.

In the meantime, as the demand for gas increases and as Eskom seeks to decommission some of its older, dirty, coal-fired power stations, these could be sold to private, independent power producers which would convert them into gas-fired power stations.

This proposal is not new but is sensible given the fact that so much of the infrastructure and equipment is already in place at such power stations.

If one generating set were to be converted to gas at a time, a steady gas ramp up would be achieved while gradually reducing the labour requirement and coal demand of the existing power plant. This would address concerns of the labour unions and coal producers.

The long game

Increased gas availability would stimulate demand until a point is reached where shale gas development and linking to existing distribution is bankable.

Competition in shale gas development has the potential for gas prices to move toward international benchmarks such as Henry Hub, which are significantly lower than South African gas prices.

The ultimate vision is a South Africa with a substantially lower carbon footprint utilising the locally available shale gas. This gas would be distributed from the Karoo gas fields to Cape Town and Gauteng.

The existing Lily gas pipeline would link to Richards Bay with a coastal pipeline to Cape Town closing the loop.

This would make cost effective, clean gas available to most consumers. The positive cycle is enabled by the key first steps of IRP2019 approval and FSRU deployment.

I believe that gas has a great future and that the next ten years will be hugely exciting.

Contact Ken Gafner, SDE,
Tel 011 997-2340, keng@sde.co.za

Fig. 1: Typical FSRU application. A FSRU is permanently moored at an adjacent quay. An LNG tanker moors alongside and transfers LNG cargo to the FSRU. Land based storage can be added later as required (Photo courtesy of Excellerate).
Greater flexibility in electricity generation essential, delegates hear

By Roger Lilley, EE Publishers

Renewable energy has changed everything because renewable energy is the cheapest technology for generating electricity in most parts of the world today. This, according to panelists at a recent seminar held in Johannesburg, will make fossil fuel-fired and nuclear power generation redundant, particularly when coupled with energy storage technologies whose prices are decreasing rapidly too.

As he welcomed more than 220 delegates to the “Flexible power generation: a new paradigm and an alternative to ‘baseloadism’”, the fourth in a series of five Energy Dialogues, Chris Yelland, the MD of EE Publishers which, together with Nedbank, hosted the event, said that the massive price reduction of clean and renewable energy from wind-powered and solar photovoltaic (PV) plants over the last five years has brought about a radical change in the way electricity is generated in many parts of the world.

“There is no economic, technical or other reason for the majority of South Africa’s new generation capacity requirements not to be met by wind and solar PV capacity, backed up by flexible generation capacity,” Yelland said.

Wartsila’s Stefan Nygard, said that because the real cost of renewable energy had fallen sharply in recent years, in two-thirds of the world renewable energy accounts for 20% of the electricity generation mix. As a result, this technology has reached what he called a tipping point, meaning that the penetration of renewable energy in the generation mix will continue to grow.

When it reaches 80%, Nygard told the audience which had filled the Boardman Auditorium at Nedbank’s offices in Sandton, renewable energy will take over as the principal source of energy supplying the majority of the permanent load, which is also known as base load. At this point, thermal power generation, from coal-fired power stations and nuclear power plants will become redundant, leaving power utilities with stranded assets. Water-based pumped storage schemes will give way to battery storage and gas-fired peaking plants, Nygard predicted.

Clyde Mallinson agreed, saying that renewable energy, with energy storage, is the cheapest and cleanest technology to use today and is the only sustainable option available. He said that for storage to work, one must have a surplus of supply. He explained that system operators balance the demand and supply by controlling demand – through curtailment, such as general load-shedding (in extreme cases) or by requesting large energy users to reduce load – or by adding additional generation capacity from so-called peaking plants which operate for short duration, usually at far higher cost to the utility, until the load has reduced.

He showed, graphically, that by generating more electricity than is needed and storing the excess, expensive peakers will be unnecessary. If the electricity is generated by the cheapest method available, i.e. renewable energy, the combined cost, per kWh, of the “over-generation” and storage will be cheaper than using coal-fired power and gas-fired or diesel-powered peaking plant.

Stephan Vermaak, from the IFC, said that financial institutions are not willing to support new fossil-fuel based generation technologies such as coal and heavy fuel oil, and that funding for new gas-fired plant will become more difficult in the future. Financial institutions, he said, want to be able to assure their investors and depositors that they take environmental concerns seriously.

Society, he said is becoming more aware of, and sensitive to, the risk to the environment the use of fossil-fuels for power generation and transportation poses, and that these concerns are behind the development of electric vehicles and renewable energy generation systems.

Vermaak suggested that South Africa accelerate the use of gas in combination with wind, solar and energy storage and minimise the use of coal for electricity generation. To this end, he said, the IFC will fund a gas terminal at Richards Bay.

The audience heard that while some people are concerned that closing coal mines and coal-fired power stations will increase South Africa’s unemployment...
A collaborative effort between major players in the wind energy industry are creating a non-profit industry body which will work across sixteen countries to ensure wind power is fully utilised in the journey towards universal access to sustainable energy services in Southern Africa, while boosting jobs, skills and economic development.

This collaboration resulted in the launch of Wind SADC, a regional wind association for the Southern African region, helping countries and companies benefit from this renewable, economically attractive energy source that has grown rapidly in South Africa.

The launch took place at this year’s Windaba event in Cape Town. Windaba is hosted by the South African Wind Energy Association (SAWEA) in partnership with the Global Wind Energy Council (GWEC) to provide the most relevant and current wind-sector information to strengthen the African wind-power industry.

The collaboration is between the Africa-EU Energy Partnership (AEEP), GWEC, SAWEA and SADC Centre for Renewable Energy and Energy Efficiency (SACREEE). It will create a non-profit industry body which will work across sixteen countries to ensure wind power is fully utilised in the journey towards universal access to sustainable energy services in Southern Africa – while boosting jobs, skills and economic development.

Southern Africa simultaneously has a very high number of people without access to sustainable energy services and superb endowments of renewable energy resources, including solar, wind and hydro. Wind and solar seem set to anchor the global energy transition. South Africa, since 2012 has seen 22 operational windfarms, with more than 900 wind turbines spread out over three provinces, installed which together produce 2078 MW of electricity. Wind power now supplies 52% of the country’s renewable energy at a cost of 33% of the renewable energy bill. Many countries in the SADC region have similar potential and would benefit from an industry body to ensure that wind power is fully utilised.

Wind SADC will promote wind energy in the Southern African Development Community (SADC) by acting as an umbrella body to its members, including industry associations from the wind sector in SADC countries. The wind industry can be a major player in powering Africa’s growth, creating new jobs and building local supply chains.

Broader socio-economic benefits can be expected: across renewable technologies in South Africa, local communities have already benefited from over R1-billion spent by IPPs on education such as upskilling of teachers, extra teachers and classrooms, and 600 bursaries to students from disadvantaged communities; the provision of health facilities and medical staff; social welfare such as feeding schemes; support to old age homes and early childhood development and the support of and establishment of more than 1000 small enterprises. The renewable energy sector is currently four times more employment-intensive than South Africa’s coal and nuclear industries.

The electricity grids in several SADC countries are modest and would not attract renewable energy players on their own. A regional approach however, would open the potential of the entire SADC region and help to foster information sharing, build visibility and coherence, and ensure that all the countries in the Southern African region – no matter the size of their wind energy industries – benefit from wind energy’s potential. This, while sharing the cost of an association across the region.

The association will work to improve the regulatory and policy frameworks in countries in the region, helping to enhance the business environment and develop capacity. Moreover, the new association acts as the central interlocutor to help tap into additional finance for energy and development in the region.

Speaking at the launch of the association, Atef Marzouk, the head of the African Union Commission’s energy division, emphasising the importance of regional collaboration on energy across the continent, said: “The launch of Wind SADC supports regional integration and economic cooperation – within the industry and beyond. It strengthens trade between member states, supporting our ambitious goal towards an African Continental Free Trade area as outlined in the AU Agenda 2063. Importantly, it also helps build energy capacity, unlock economic development and collaboration between countries in energy.”

Ntombi Ntuli, the CEO of SAWEA says her association will contribute existing capacity and experience. “Having an established office for more than 8 years and having been the custodian of explosive industry growth in South Africa, we will support Wind SADC with back office services and the lessons learnt over almost a decade. We look forward to contributing to regional growth,” she said.

Speaking of its role in supporting the association, Ben Backwell, the CEO of SAWEA said: “We are excited to support Wind SADC to ensure wind energy is fully utilised in the journey towards universal access to sustainable energy services in Southern Africa.”

Continued on page 10...
Addressing the fourth industrial revolution challenge

The Association of Municipal Electricity Utilities (AMEU) held its 27th technical convention at the Cape Town International Convention Centre recently. The theme of the convention, “Building the power utility of the future, today” addressed a number of challenges associated with modern technology – what has become known as the fourth industrial revolution, a term coined by Klaus Schwab, the founder and executive chairman of the World Economic Forum, in 2016.

These challenges, which arise from the exponential growth in digital processing power, will have a significant disruptive effect on the way in which things are done in future. Municipal electric networks will not escape the changes. Already, many businesses and homeowners are becoming electricity generators, and wish to sell excess power to their municipalities.

The president of the AMEU, Releifo Mokosi, said that the conundrum of what actions municipalities should take today to prepare them for the future, must be solved. These challenges include declining revenues, ageing infrastructure and the need for new network configurations to address the development of distributed generation.

In his keynote address to the convention, Gwede Mantashe, the minister of mineral resources and energy, said the shift away from the traditional vertically integrated power system to private, independent power producers which generate power for their own needs, will have a negative effect on municipal revenues. Municipalities which wish to increase tariffs to increase their revenues however, will find this to be counterproductive.

The way forward, Mantashe said, is for municipalities to offer cost-effective services which make residents desire to buy power from them.

Xolile George, the CEO of the South African Local Government Association (SALGA) said that it would be senseless for municipalities to resist the changes which emerging technologies will introduce, and that all role-players should embrace the changes and reconfigure the industry to ensure that those whose jobs may be at risk are reskilled and that reliable, affordable electrical supply is available for everyone in South Africa.

Follow this link to download the convention proceedings: https://wp.me/p5dDag-1ezB

...continued from page 8

rate, studies show that multiple, utility-scale renewable energy projects will create more job opportunities than those in the coal industry.

Chris Forlee, the CEO of the National Energy Regulator of South Africa (Nersa), said that the regulator’s task is not to prescribe technologies since it is technology agnostic. Rather, the regulator sets tariffs which ensure that the government’s energy policies are fulfilled cost effectively, while making sure that investors are able to make a fair profit.

Forlee said that modern technologies, working together, have brought us to the fourth industrial revolution (4IR). This development will have dramatic effects in the electricity sector, introducing smart grids in both transmission and distribution networks.

For this reason, Forlee said, the government is setting strict parameters regarding the introduction of privately generated electricity into existing distribution grids. In some cases, a ministerial determination is made, and a generating licence must be applied for. In other cases, one must simply register the generation plant to enable the Department of Energy know how much private generation is in use.

The grid code is to be amended next year, Forlee said, to make allowance for energy storage which will be consider a generator, since, like pumped storage, it is able to supply power to the grid.

The panel agreed that there are many challenges facing South Africa’s energy sector, but many opportunities will arise, particularly in gas-to-power and mini-grid technologies. Renewable energy is here to stay, the panel said, which will ultimately replace older generation technologies. However, for this to occur, the existing grid will need to be strengthened and restructured to accommodate new applications such as electric vehicles which may be charged in one location and discharged elsewhere.

However, the first and most important task the power utilities should address, the panel said, is the collection of payment for electricity consumed. Unless this problem is effectively overcome new investment in the energy sector is at risk, the audience was told.

Nedbank’s Thabang Chiloane chaired the panel discussion and took questions from the audience during the question-and-answer session.

Send your comments to energize@ee.co.za
New alliance to help navigate the complexities of the carbon tax

Two leading consulting firms – Cova Advisory and Xnovos – have announced a new partnership to produce a software system to help companies to cope with the demanding requirements of the new carbon tax. They have signed a memorandum of understanding, and are committed to helping meet demand for a comprehensive support package to simplify the administrative burden which has arisen with the tax.

“We already offer consulting services to a lot of big corporates on tax, with a tax accounting software package called TaxPacc that manages the corporate income tax lifecycle,” said Eric Roberts the CEO of Xnovos. “Now we have a joint-venture with Cova Advisory to apply the same logic to help corporates manage the carbon tax.”

The aim is to combine Xnovos’ knowledge of developing software to manage complicated tax calculations with Cova’s in-depth understanding of the complexities of the carbon tax, and its painstaking monitoring of legislative and reporting changes. The target market for the new product will be large corporates such as mining, steel, and chemicals companies, as well as manufacturers.

“Firms which sign up to this new joint offering will enjoy continued support,” said Cova partner Duane Newman. “We will ensure that the package is updated with legislative changes and any new reporting requirements.”

Since 2017 companies are obliged to submit greenhouse gas emissions reports to the Department of Environment, Fisheries and Forestry by end of March, and from 2020 they will also need to submit carbon tax returns and pay carbon tax by end of July.

“Where we come in is that we help manage the information flow and calculations to automate the preparation of the reports and returns, which ensures they are accurate and aligned with each other,” said Roberts.

Tumelo Chipfupa, founding partner at Cova comments “The process can often be messy. It may sound obvious, but carbon tax is a niche specialty where you need to understand both carbon emissions and tax.” Information for assessing carbon tax liabilities must be obtained from different sources – such as the foreman at a smelter, a company’s invoices, with input from environmental experts. This has all then to be processed to assess a firm’s carbon tax liability.” The new software is currently being developed to be ready to meet the March and July deadlines in 2020.

Contact Eric Roberts, Xnovos, Tel 083 633-6022, info@xnovos.com

Renewal and modernisation at NETFA

Various organisations and industry associations met at the South African Bureau of Standards (SABS) recently for the first planning meeting of the Technical Advisory Committee (TAC). The National Electrical Test Facility (NETFA) TAC was launched on 30 July 2019 to create an open and inclusive platform for a broad group of electrotechnical stakeholders to advise on the renewal and modernisation of NETFA.

NETFA is the largest independent test facility for power utilities and the electrotechnical industry within Africa and has been providing services since 1980. The test facility, based at Olifantsfontein, Gauteng, is equipped with indoor and outdoor high-voltage test facilities, a short-circuit test laboratory and a materials and installations laboratory. NETFA provides services to a wide range of local, African and international clients in fields such as electricity generation and distribution, mining equipment, asset management and electronics manufacturing.

SABS executive, Laboratory Services Division Johan Louw says while the SABS has regularly invested in maintenance and upgrades, it has reached a point where it must recapitalise NETFA strategically to meet current and future test demands. The renewal must be done with the support and inclusion of the industry it supports. He says the collective expertise of the TAC will be invaluable in determining the success of the modernisation effort,” says.

Key industry stakeholders who make up the NETFA TAC will ensure alignment of the capital investment plans to the pace and development of the industry. Various workgroups will be created to ensure a broader and deeper engagement to the proposed strategy and implementation plan.

“NETFA must support the local economy with relevant, cost effective conformity assessment services. The upgraded facility will be better able to meet the requirements of local and international standards, as well as customer-specific requirements. Products that are tested successfully at NETFA will enhance South Africa’s export potential and support job creation,” says Louw.

In March 2019, the Department of Trade and allocated R300-million to SABS over a three-year period for the purposes of upgrades to critical infrastructure. R95-million was earmarked for infrastructure upgrades and included NETFA.

Contact Roshelle Pillay, SABS, Tel 012 428-6878, roshelle.pillay@sabs.co.za
Conference addresses the integration of DER for power system development

Cigré is uniquely positioned as a community of thought leaders, decision-makers, and technology leaders across the world with power system expertise and forward-looking thought leadership to improve electricity infrastructure for society.

This is the view of Rob Stephen, Cigre’s international president. Speaking at the organisation’s recent conference and colloquium, which were held at the Misty Hills conference centre, Muldersdrift, Stephen said that the organisation is uniquely positioned as a community of thought leaders, decision-makers, and technology leaders across the world. Power system expertise across the globe offers technology and professional development for both those young in their careers and for those more seasoned members.

The joint event took place between 1 and 3 October 2019, with the theme of “Sustainable integration of distributed energy resources (DER) for power system development”. The event was attended by 330 delegates from 31 countries. A total of 88 papers, selected from 140 submissions, were presented. The conference also incorporated the Cigré Women in Engineering (WiE) forum.

Today, Stephen said, as the organisation approaches its second century, its new strategy and brand “end-to-end (E2E) power system expertise”, which was inaugurated in Paris in 2018, will set the organisation’s scope for the grid, the globe, and all that seek sustainable and affordable electricity. Thousands of volunteers across the globe in 16 Study Committees and over 200 Working Groups are developing technical material on every conceivable subject for power system expertise, he said.

In his welcoming address, the South African National Committee (SANC) chairman, Prince Mayo, stated that Cigré now follows an end-to-end approach, which embraces all sectors from generation to distribution. This change became necessary to accommodate changes taking place in the industry.

SANC consists of more than 200 members but would like to grow its numbers, he said, but the recent decision by many organisations not to sponsor membership of voluntary associations for employees could be an inhibiting factor. Discussions with other national committees reveal that most members pay their own membership fee, and he hopes that this will be the case for South Africa in future.

Cigré and the world bank are cooperating to achieve common goals of transferring knowledge to facilitate development of the electricity sector and access to electricity in Africa focused on different target groups; and the definition of a financial framework for training workshops and implementation support consulting, for topics related to Cigré’s work products, aimed to address cost and efficiency concerns of African countries and the world bank.

Conference summary

The technical sessions started with a series of presentations on battery energy storage systems (BESS). BESS is an attractive solution to network problems as it has the capability of being able to generate and consume real power through its inverter capacity, as well as absorbing and releasing reactive power. Energy storage is finding use in HV, MV and LV in both grid-connected and stand-alone mini-grid networks. BESS has the potential to provide a variety of services including arbitrage, ancillary services such as frequency control, voltage support and black start, peak shaving; as well as transmission and distribution congestion relief. BESS is also used to smooth the power output of renewable energy systems and provide stored energy in micro-grids when the prime source is not operational (such as wind and solar).

Papers presented at the conference showed that the use of BESS could provide congestion relief and delay upgrades on both HV transmission systems and MV radial feeders. Where high PV penetration occurred on radial feeders, BESS could be used to alleviate problems with voltage control.

A unique aspect of BESS is the possibility to “stack” the benefits these systems provide. As an example, a grid-scale battery installation could provide an opportunity for deferment of capital and simultaneously provide national peak-load shaving as well as loss reduction by local load/generation balancing and enhanced network reliability. By capitalising on the multiple revenue streams BESS may offer, it is more likely that a positive return on investment may be achieved.

The biggest problem facing the use of BESS is the lack of appropriate legislation. Given the different applications of BESS, these could be seen as loads at times and as generators at other times, with different regulations applying to the two cases. Regulations differ worldwide and South Africa has no specific regulations concerning BESS at present.

Following the theme of the conference, a large number of sessions focused on integrating renewable energy (RE) sources into the network, covering a wide variety of topics. The integration of small-scale embedded generators (SSEGs) in the distribution network poses challenges on voltage level control and system balancing, and several papers covered solutions to this problem. Intermittency of RE connected at the MV level is a common problem, and several solutions to this were proposed, including curtailment. The introduction
of SSEGs into distribution networks has an impact on revenue and a solution for this, using different charging schemes, was discussed.

The introduction of a large number of inverter-based generators, which have little or no inherent inertia, into the grid has an effect on grid stability during disturbances, and this needs to be taken into consideration when planning networks, delegates were told.

Rooftop solar PV systems are being used extensively in this country and several papers discussed the present and future use of these systems. The addition of storage to rooftop solar PV is seen as being advantageous in future when prices decrease further.

There is often a mismatch between RE generation and load, particularly with wind, delegates heard. This results in over generation. Several solutions to address this problem were suggested, including tariff incentives, curtailment, storage and increasing the flexibility of the existing conventional generation fleet. The need for flexibility in future networks was discussed in several papers.

Other topics included virtual synchronous generator control, artificial inertia, safety pertaining to rooftop solar PV, and lightning protection. Other sessions covered markets and regulations, power transformers, power lines, development of small nuclear reactors and emerging technologies.

**B4 colloquium**

*The B4 study committee covers HVDC and power electronics*

The committee reported that DC transmission traditionally refers to HVDC, but is moving into the MV transmission and distribution area. The recent rapid growth of the renewable generation has made these systems weaker (i.e. less short-circuit current and less inertia) and for some of the HVDC systems, the system strength is much lower than the minimum levels predicted at the design stage. These conditions may cause problems for the HVDC systems, the committee said. Unacceptable dynamic performance, harmonic resonances, controller instabilities and sub-synchronous frequency oscillations are some of the issues.

Multi-terminal HVDC systems are becoming popular and the operation of these systems was discussed in several papers. Future proofing of HVDC, including lifetime extension, and improving HVDC reliability featured in several papers. Other papers focused on HVDC technology, VSC systems and other FACTS devices.

**Closing session**

The joint closing session focused on regional interconnections, and featured papers on both HVAC and HVDC systems. HVDC is finding an increasing use for interconnections because of its inherent frequency and phase independence.

**Best paper awards**

A Guan won the best paper award for his paper “Loss optimised design of air core reactors”.

The best young engineer paper award went to MT Maleafatana for his paper “Electroluminescence imaging characterisation for PV modules”.

The best student paper award went to HF Mnisi for his paper “Investigation of the application of dissolved gas analysis (DGA) in canola-based natural ester oil under arcing fault”.

Send your comments to energize@ee.co.za
Southern Africa is moving towards becoming a top global wind energy destination. Enabling factors include an exceptional resource and a growing recognition that wind power can help plug Africa’s energy gap, attract investment, foster economic growth and create jobs.

Speaking at the Windaba 2019 conference at the Cape Town International Convention Centre, Gwede Mantashe, the minister of mineral resources and energy said that the wind sector can play an important part in South Africa’s economic growth. South Africa remains the continent’s wind powerhouse, but other countries are catching up fast, experts said during the 2019 Windaba conference.

In terms of energy generation capacity, Africa’s energy mix is no longer confined to oil, coal and gas. According to estimates by the Global Wind Energy Council (GWEC), the Southern African Development Community (SADC), a region comprising 16 countries, alone has a wind energy potential of around 18 GW. “This is one-third of the region’s current power pool,” said Johan van den Berg, Head of the Africa-EU Energy Partnership (AEEP) Secretariat. “The East Coast of Africa, stretching from Northern Mozambique to Kenya, has a huge potential.”

Other wind energy hotspots include Mauritius, Zambia, Namibia, and Tanzania, added Ntombifuthi Ntuli, CEO of the South African Wind Energy Association (SAWEA). “Namibia’s National Integrated Resource Plan calls for 149 MW of wind energy to be developed by 2035,” she said. “Tanzania, in the meantime, has plans to develop four onshore wind energy projects with a total capacity of 550 MW. Recently the country announced a 300 MW wind farm of which construction will start soon.”

According to SAWEA statistics, South Africa’s wind IPPs helped create 10 099 job years since 2011. That is a third of all job-years created by all 112 renewable Independent Power Producers (IPPs) that fall under the REIPPP. “South Africa’s engagement has allowed the development of a vibrant industry on the continent and has contributed to creating local employment in the sector,” Canete said.

Southern Africa is moving towards becoming a top global wind energy destination. Enabling factors include an exceptional resource and a growing recognition that wind power can help plug Africa’s energy gap, attract investment, foster economic growth and create jobs.

Southern Africa is moving towards becoming a top global wind energy destination. Enabling factors include an exceptional resource and a growing recognition that wind power can help plug Africa’s energy gap, attract investment, foster economic growth and create jobs.

Speaking at the Windaba 2019 conference at the Cape Town International Convention Centre, Gwede Mantashe, the minister of mineral resources and energy said that the wind sector can play an important part in South Africa’s economic growth. South Africa remains the continent’s wind powerhouse, but other countries are catching up fast, experts said during the 2019 Windaba conference.

In terms of energy generation capacity, Africa’s energy mix is no longer confined to oil, coal and gas. According to estimates by the Global Wind Energy Council (GWEC), the Southern African Development Community (SADC), a region comprising 16 countries, alone has a wind energy potential of around 18 GW. “This is one-third of the region’s current power pool,” said Johan van den Berg, Head of the Africa-EU Energy Partnership (AEEP) Secretariat. “The East Coast of Africa, stretching from Northern Mozambique to Kenya, has a huge potential.”

Other wind energy hotspots include Mauritius, Zambia, Namibia, and Tanzania, added Ntombifuthi Ntuli, CEO of the South African Wind Energy Association (SAWEA). “Namibia’s National Integrated Resource Plan calls for 149 MW of wind energy to be developed by 2035,” she said. “Tanzania, in the meantime, has plans to develop four onshore wind energy projects with a total capacity of 550 MW. Recently the country announced a 300 MW wind farm of which construction will start soon.”

South Africa, however, remains Africa’s top wind energy leader. Between its inception in 2011 and March 2019, the country’s Renewable Energy Independent Power Producer Procurement (REIPPPP) programme has procured 3366 MW from 36 independent wind power producers. “Besides strengthening our overall energy security, the South African wind energy sector has attracted R80,6-billion worth of investments since 2011, of which Foreign Direct Investment (FDI) accounted for R13,2-billion,” said Ntuli.

A strong political will has been a crucial ingredient in these achievements, Ntuli said. “The value of the leadership demonstrated by the government at the moment cannot be understated – it is directly driving the return of investor confidence,” she explained.

A second but no less important role player in creating and developing South Africa’s wind energy ecosystem has been the quality of the resource. “A study by the Centre for Scientific and Industrial Research (CSIR) indicates that the wind resource potential in South Africa is extremely good. It has concluded that wind turbines with extraordinarily high load factors could be operated on 80% of our surface area, along the coast but also inland,” Ntuli said.

Miguel Arias Canete, Commissioner for Climate Action and Energy at the European Commission, noted that developing a wind energy ecosystem in South Africa has not been just about generating clean and affordable power and attracting investment. It is also about stimulating job creation.

According to SAWEA statistics, South Africa’s wind IPPs helped create 10 099 job years since 2011. That is a third of all job-years created by all 112 renewable Independent Power Producers (IPPs) that fall under the REIPPPP. “South Africa’s engagement has allowed

Gwede Mantashe, minister of mineral resources and energy.
Senegal enters the LNG race

Senegal has made some substantial deep-water gas finds. This West African nation, where oil was discovered in 1961, expects all its offshore projects to come online between 2022 and 2026. According to the International Monetary Fund, between 2014 and 2017, oil and gas reserves worth more than 1-billion barrels of oil and 40-trillion cubic feet (tcf) of gas, most of it shared with Mauritania, were found. The Greater Greater Tortue Ahmeyim LNG project will produce around 2.5-million tonnes per year, with first gas expected in 2022.

Kenya pioneers geothermal energy

Geothermal resources produce far fewer CO₂ emissions and, unlike solar and wind energy, are always available. The potential of geothermal energy in East Africa is enormous. With resources estimated at approximately 15 GW in the Rift Valley, various countries in the region have started to explore this great potential, both with public and private project developers. Kenya has an installed capacity of 676 MW. Other countries are now trying to catch up in this technology, due to the numerous benefits that it can bring to their national power markets and economies.

Zambian solar tariffs cheapest in Africa

Zambia will participate in the World Bank/International Finance Corporation (IFC) Scaling Solar programme to unlock private-sector investment for solar power in emerging markets. USAID has provided US$2-million to IFC to support Scaling Solar Zambia, and the Overseas Private Investment Corporation (OPIC) has provided a $13-million loan to the Bangweulu project, developed in consortium by First Solar and Neoen. Zambia is also modernising its electricity systems to bring renewables onto the national grid. A competitive procurement process resulted in solar tariffs of between US$0.06 and $0.078/kWh.

Namibia to add 220 MW wind and solar power

Nampower intends to tap into abundant solar and wind energy, as well as biomass, resources to build four renewable power plants across the country. That would be a significant addition in a country with one of the lowest population densities in the world. National power generation capacity totals an estimated 557 MW, some 347 MW of it hydroelectric, and nearly half the population, around 1-million residents, many of whom live in rural areas, lack access to modern electricity services.

Partnership promises clean energy

A new partnership will tackle battery waste in Kenya by repurposing old battery packs. Aceleron, a UK-based developer of sustainable and reusable battery solutions, and Total Access to Energy Solutions (TATES), are committed to providing off-grid Kenyans with cleaner and more affordable power. The first stage will see Aceleron convert TATES’ and its partners’ waste lithium-ion battery cells into repairable, upgradable and affordable long-cycle reusable battery packs to bring clean power to more than 800 people in off-grid communities across Kenya.

Largest solar farm in east Africa

Williamson Tea’s 1 MW solar project on one of its farms in western Kenya is the largest so far in east Africa, and is one of only six existing projects in the world to use a technology known as Solar Fuel Saver (SFS), allowing it to work in parallel with the national grid or, when the grid is down, with standby diesel generators. It has been estimated that the project will save Williamson Tea 30% of its total energy costs.

Trans-Sahara natural gas project

The Trans-Saharan natural gas pipeline, which is also known as the NIGAL pipeline, is due to extend from the Warri region in Nigeria, up through Niger to the south of Algeria and from there to Spain. It is expected that the pipeline, which is estimated to be about 4400 km in length, is one of the world’s most expensive. Once complete, expectations are that it will carry up to 30-billion m³ of natural gas a year to markets in the European Union.

Tanzanian gas pipeline leaking

This 532 km long pipeline runs from Mvemba Bay in the Kilwa District in the south of Tanzania to the city of Dar es Salaam. However, according to Nigel Whitaker, the managing director of Songas Tanzania, the pipeline is leaking near or at the natural gas station in Somanga-Fungu, a village in south-eastern Tanzania. The pipeline is designed to carry an estimated 784-million cubic feet of gas per day, for use in producing 3.9 GW of electricity. The estimated cost of the project was $1.3-billion.

Ghanaian independent power plant

The Kpone Independent Power Plant (KIPP) is among Ghana’s most fuel-efficient thermal power stations and critical to keeping the lights on and meeting the country’s growing demand for electricity. Developed by Cenpower Generation Company Limited, KIPP accounts for approximately 10% of Ghana’s total installed capacity and is among the largest private independent power producers in the country. USAID provided direct transaction advisory support to the Electricity Company of Ghana and helped attract investors to finance the transaction. The plant employs at least 70 people full-time during operation.

energize - Nov-Dec 2019 - Page 15
All solar PV installations, irrespective of type and installation method, suffer from soiling in some form or the other. Soiling is the deposition of a coating of material, mainly dust, on the surface the panel, which blocks out some of the radiation reaching the PV cells. Soiling is due to airborne particles settling on, and remaining on, the glass surface of the panel.

Soiling is a complex process which occurs as a result of the dust originated from a variety of sources such as windborne pollutants, airborne liquid constituents, particulates from construction, mining and pollen. The dust gets suspended atmospherically in some manner, including wind and diffusion, and gravity causes it to settle on the panel. The rate of soiling will depend on the amount of dust in the air, but can be affected by other factors such as wind speed, etc. Another factor contributing to soiling is the adhesion mechanism, which is affected by the surface texture of the module, tilt angle, humidity/moisture and re-suspension [3].

These materials can be present in the air and on the module in different combinations and forms; such that the type of shading that occurs can be considered either 'soft’ or ‘hard’ shading: Soft shading takes place when haze particles such as smog or light dust on the module reduces the overall intensity of the solar irradiance which reaches the solar cells. Hard shading occurs when a more solid type of dust or material (such as bird droppings) blocks the sunlight in a definable shape [5].

These two types of shading have different effects. Soft shading affects the current generated by the PV module, while the voltage remains the same. With hard shading, the performance of the module depends on how many cells are shaded, and where they are in the module, and can affect both current and voltage produced.

Humidity and dew point are two other factors affecting soiling. These factors essentially influence cementation, which is the process of dust particles sticking to the surface of the PV module and to one another. During cementation the chemical nature of particles themselves changes due to presence of water. These particles can become glued to the glass, making the removal process more difficult.

The solar panel itself can cool down to a level at which dew forms and these droplets themselves contain dust. This impacts soiling through its stickiness and ability to form a more permanent bond to the surface. Dew formation is only beneficial if it is large enough to cause run-off, in which case it will actually help clean the panel. Studies have shown that a small amount of dew or rain does more harm than good, even in hot climates. There is a minimum amount of water required at a specific tilt, for a certain type of glass surface and a specific contact angle, to allow dew and rain to clean the panels.

Soiling occurrence
Soiling varies from site to site and can vary seasonally as well. Soiling can be affected by rainfall, where regular rain can remove some of the material. Light precipitation can have a negative effect, by causing clumping of material with resulting irregular soiling, and by forming a solid paste which is difficult to remove.

Fig. 1 shows the dust potential of different sites around the world.

It can be seen from Fig. 1 that the major solar energy producing areas in South Africa lie in high to very high dust potential areas, making control of soiling an important aspect of operations.

Effect of dust on output performance
Soiling reduces the output of a PV panel. The optical loss caused by dust on solar collectors is considered to be the third most important meteorological input, after insolation and air temperature, that determines energy yield in a photovoltaic power plant [1]. Without cleaning, losses can climb to as high as 20% over a month and in some studies even higher figures are mentioned.

To manage power losses caused by dust, standards for PV system performance monitoring suggest the use of the soiling ratio (SR) as a measure of the extent which the panel is affected. The SR is the ratio of the actual power/current output of a PV array under given soiling conditions to the power/current that would be expected if the array were clean.
and free of dust. Measuring the S/R ratio provides information needed to make practical decisions, such as scheduling solar panel cleanings, which can better optimise the performance of plant.

The soiling ratio SR is defined as the instantaneously measured ratio of dirty-to-clean (test-to-control) module outputs at any given point in time and is often defined in terms of effective irradiance received by each module:

$$SR = \frac{G_{dirty}}{G_{clean}}$$  \hfill (1)

where $G_{dirty}$ and $G_{clean}$ are the effective irradiance and are determined from the temperature-corrected and normalised short-circuit current measurements of each module.

**Measurement of soiling**

Control of cleaning operations varies from time-based schedules to condition-based systems. For larger systems where the rate of soiling varies over time, the condition-based system is generally chosen. To operate a condition-based system, it is necessary to be able to measure the extent of soiling. Soiling has the impact of reducing the output of the panel, and the extent can be measured by comparing the output of a standard soiled panel to a standard clean panel placed at the same location in the installation. This method has the advantage of measuring the effect of dirt directly and is independent of type and colour of dust. A free-standing typical instrument used for measuring soiling is shown in Fig. 2. A more advanced system using a small reference cell with automatic cleaning of the reference cell, and which can be used in stand alone or integrated version is shown in Figs. 3 and 4.

A variation on this theme is the indirect system of Kipp and Zonen (K&Z) which uses the reflective effect of a dirt coated glass surface (Fig. 5).

The device is a relatively small device, weighs around 4 kg and is daisy chainable, which enables the operators to connect multiple devices to form one string throughout the system.

**Cleaning methods and programmes**

Currently employed soiling mitigation strategies include rainfall, high-pressure fresh-water jets, automated air jets, automated mechanical brushes, and surface coatings on panels.

**Natural cleaning (rainfall)**

Natural cleaning relies on rainfall to remove dirt from the panel surface. Rainfall is free of charge but seasonally variable, and this affects the reliability of this cleaning especially when soiling is intense and rainfall is insufficient, either in quantity or in intensity, to wash off the dust. The data gathered from some studies indicate that a light rain, the efficiency of some PV panels declined sharply, whereas the performance of other panels was improved, leading to the conclusion that at least 20 mm of rainfall is needed to clean the surface of PV system.

The panel elevation will also affect the efficiency of natural cleaning. A low elevation will result in a higher amount of water per unit surface area, but the water will run off more slowly. Higher elevation gives faster and more effective runoff, but less rain per unit surface area. Systems located close to the equator, with a low elevation, will differ from systems located further away.

Attempts have been made to increase the cleaning effect of rain by using hydrophobic and hydrophilic antireflective coatings. Tests undertaken over periods of both scarce and frequent rainfall show that improved natural cleaning can be achieved by this method.

**Manual cleaning**

Manual cleaning is still undertaken but is limited to areas where labour is available, and the site is relatively small. Manual cleaning is most commonly used for rooftop systems.

**Mechanical cleaning**

All large installations will use machinery of some form of the other for cleaning.
The simplest form is simulated rainfall, i.e. water sprays from a fixed system. This requires a large amount of water and a large amount of maintenance but has found application in large rooftop systems which are difficult to reach.

Mobile cleaning systems mounted on a tractor or other vehicle capable of moving over irregular surfaces taking its cleaning material with it, offer the benefits of a lower cost of equipment and the fact that the cleaning can be focussed and varied on different sections of the array. Larger robots are able to clean up to 2000 m² per hour [3].

Automatic robotic cleaning equipment is attached to the PV framework and moves under its own power along the array. Many of the systems available are water-free cleaning systems, and in some cases, a daily cleaning cycle has been found to be economical. The robotic system offers the ability to recover from environmental issues such as dust storms in a very short time.

Cleaning frequency

Studies have focused on determining the optimum cleaning interval using measured parameters, which can change with time and seasons. Most attempt to balance the cost of losses due to soiling with the cost of cleaning. A very simple model has been developed by Solarrus [7]. This uses an approach that acknowledges there are circumstances where washing frequency can be calculated based on measured parameters. It starts by constructing a mathematical model that describes the effects of soiling and cleaning on the optimal washing frequency at a solar site, a makes number of simplifying assumptions:

- The loss of power generation and revenue due to soil accumulation occurs at a constant rate, i.e. is linear.
- Washing is paid at the time of service in a lump sum and instantly restores power generation to 100% of its theoretical output.
- Seasonal and weather affects are not considered in the basic model used to derive the optimal cleaning interval.
- There is no output capping or curtailment.

The real world is not as simple as these assumptions, but models are frequently constructed for a simplified world in order to understand the basic relationships between variables. The initial simple model is highly instructive and generally reflects the overriding principles at work in the process.

Application of this method yields an optimum washing period of:

\[
T = \sqrt{\frac{2W}{r}}
\]  

where:

- \( W \) = The cost of washing (rand).
- \( T \) = The time between washes (days).
- \( r \) = The rate of revenue loss due to soiling (rand/day/day: $(R/day^2)$).

Mitigation of soiling

Soiling is a natural occurrence, which cannot be intrinsically prevented, but it
is possible to mitigate its negative effects by several methods.

**Frameless panels**

Framed panels suffer from the problem of accumulation of dirt on the edges where the glass of the panel fits into the frame. Rainwater falling on the panel dams up at this point, depending on the elevation of the panel, and can result in the redeposition of dust over a significant length. Frameless panels avoid this problem and allow water to run freely off the surface.

**Dust repellent**

Dust repellent systems make use of the properties of the glass used in PV panels. Typically, a 3,2 mm thick piece of solar glass is used. The solar glass has a rough surface. This is needed, because during the lamination process, EVA lamination needs to adhere to the glass. Completely smooth glass wouldn’t adhere well and would lead to delamination.

Most PV cells are equipped with anti-reflection coatings (AR coatings). More and more companies are striving to develop anti-soiling coatings (AS coatings) in order to either prevent soiling from occurring or mitigating the risks associated with it. Module glass, which is treated with anti-soiling coating, is expected to not only soil at a slower pace but also be easier to clean, allowing the modules to maintain their optimal performance levels for a longer time.

Environmental dust has various particle shapes and sizes and, in general, they comprise of metallic oxides, alkaline (Na, K) and earth alkaline (Ca) compounds in addition to silicon and other related elements [3]. Atmospheric water condenses onto the dust particles in the ambient air and gives rise to dissolved alkaline and earth alkaline compounds of the dust. This forms a chemically active paste solution with high pH on the surface, where dust settles in the depressions on the surface. As ambient temperature increases, mud solution dries and forms an interfacial layer between the surface and dust particles, which in turn increases adhesion between dust particles and the surface. This raises the efforts require for dust removal from the surfaces and increases the cleaning costs [3].

Hydrophobic surfaces demonstrate better performance in terms of effort requirements for dust removal from the surfaces. This is because of the weak adhesion of dust particles onto the surfaces. In general, hydrophobic characteristics of surfaces are closely related to the surface texture and low surface free-energy of the substrate material. In addition, the hygroscopic layer fills the indentations in the glass and forms a smooth surface on the panel, which further serves to repel water.

**Electrostatic dust repulsion**

A high AC voltage is applied between transparent parallel electrodes on the surface of the panel. This creates a moving electrostatic field which repels the dust particles into the air where they fall down the panel surface under the force of gravity, eventually falling off the panel. This system works well with large dry dust particles but would be less efficient with smaller water borne particles (Fig. 6). The system is said to work well in desert conditions where sand particles are the main constituent of soiling.

**References**

The references for this article can be found with the online version at https://wp.me/p5dDng-1eBH

Send your comments to energize@ee.co.za

---

**SERVICES OFFERED**

**GRID STUDIES**

PSD performs engineering simulation studies for reactive power compensation devices like SVCs and STATCOMs, high voltage series and shunt capacitor and filter banks in PSCAD ®.

**INTEGRATION OF DISTRIBUTED ENERGY SOURCES**

We offer consulting services during all stages of renewable energy projects including carrying out of Grid Code Compliance studies in DiSilent ®.

**POWER QUALITY**

We do equipment failure analysis, power quality studies and harmonic measurements.

**PSCAD ® TRAINING**

We are an accredited training provider.
The digitalisation of PV operations

All eyes are on digital technology as European PV plant operators continue to seek meaningful reductions in asset management and operations and maintenance (O&M) costs. Digitalisation promises to slash operational expenses and boost efficiency by automating many tasks that currently have to be done by hand, and by improving asset managers’ ability to rapidly identify and remedy issues affecting plant profitability.

The process of digitalisation is not without its challenges. Digital systems cost money and are not guaranteed to deliver the insights they are meant for. Choosing the right platforms, applications and integrations to invest in is not always an easy process.

The market context

The solar energy sector gets top marks for embracing digital technology. According to research by the global quality assurance and risk management company DNV GL, solar is the most advanced of any energy sector in terms of digital transformation [1]. Demand for blockchain skills by solar companies, for example, is 50% higher than in the energy sector as a whole. The use of drones is a third higher in solar than in other energy-related industries [2].

Perhaps most importantly, only 13% of solar experts claimed that lack of a digital mindset was an obstacle to digitalisation, the lowest level of any energy industry surveyed. Clearly, solar leaders are well aware of the benefits of digitalisation. That does not necessarily mean they are having an easy time with digital transformation, though.

Overcoming digitalisation challenges is a critical task for the industry as it strives to use technology to continue driving down costs.

Drivers for digitalisation

Digitalisation is relevant to almost all players in the solar value chain, according to Martin Schneider, the MD of Meteocontrol, which monitors 13 GW of power across 45 000 PV plants worldwide. “If you are an operator, you can optimise your process,” he says. “If you are an asset manager, you see how you can challenge your operator a bit more.” Perhaps one of the biggest drivers for the application of digital technologies is the high cost of manpower in the sector, particularly in Europe where skilled technicians demand relatively high salaries. “To use field service personnel very effectively is a key challenge,” Schneider points out. “Here in Europe those resources are limited. It’s about handling more plants with the same resources.”

The manpower issue is particularly acute for the growing number of operators that have portfolios distributed over large regions or across borders. Keeping a handle on the plants in large portfolios becomes very difficult without digital technology, not least because of the resources required for manual data collection and analysis.

For example, at Encavis, which has almost 2 GW of solar and wind in Italy, “the technical availability is often calculated manually by the O&M [provider],” says Saul Lazzarini, technical portfolio manager. “How can I check 64 reports? I cannot afford to do that.”

In contrast, if technologies such as supervisory control and data acquisition (SCADA) systems are linked into broader workflow and analysis platforms then a small central team can respond rapidly to events on the ground while having a broad view of operations.

The potential of the technology

Digitalisation has the potential to impact on four major areas of solar O&M. Schneider suggests the following:

Workflow organisation

Maintaining efficient workflows is key to solar cost reduction and digital systems can help asset managers to keep track of recurring tasks, such as green keeping, as well as single events such as expiring warranties. Workflow organisation systems can also provide a portfolio overview within which asset managers can assign priorities to certain parameters.

Information

Three sources of information can be managed by digital systems to improve plant performance. The first of these includes plant documentation, contract documents, warranty conditions and the like, usually stored in a document management system. Beyond this, there is extended system data, such as plant access details, service partner administration information and technician costs, and component histories.

Service management

This includes key performance indicators (KPIs) such as availability, along with work orders, reports and analyses. Companies such as Meteocontrol offer service management packages in the form of a mobile app, for use in the field. “The operator transfers what he wants to do on site and there is direct feedback,” Schneider comments. Traditionally, he says, “this kind of reporting takes a week or two weeks and is far too long. With digitalisation you reduce timing.”

Interfaces

Digital tools work most effectively when they are properly integrated into the supply chain, for example to enable spare parts management and enterprise
What digitalisation delivers today

Basic plant infrastructure such as SCADA and computerized maintenance management system (CMMS) platforms can deliver a host of insights if the data is analysed correctly. Enrique Camacho, predictive maintenance and life extension coordinator at Ingeteam Power, lists five categories of analysis that can be carried out on SCADA and CMMS data (see Table 1).

However, he notes, it is important to check the accuracy of the data before applying analysis techniques. “When we receive the SCADA or CMMS data, we use pattern analysis and neural network algorithms to know when the information is OK,” he says.

For the analysis, many asset managers prefer a mix of off-the-shelf and in-house systems, although the balance depends on factors such as the budget available for IT investment. At Encavis, for example, “it’s external,” says Lazzarini. “We don’t have the capacity to do it internally. It’s huge investment.”

Christian Ahrens, Head of Solar Asset Management at Aquila Capital, which controls 2.8 GW of wind and solar, mostly in Europe and Japan, says most of his company’s analysis systems are also external. The sole exception is for some software that was used to analyse systemic defects in a particular component.

“In our experience, it’s very important to have that kind of key software in house because if it gets really tense in court then you have to know what you are doing,” Ahrens says.

Challenges to be overcome

While the solar industry is clearly racing to embrace digitalisation, there are still considerable hurdles to be overcome. One of the main problems relates to tying together numerous IT systems acquired over time through mergers and acquisitions. “Most companies already have an existing IT landscape and when you introduce a new system or a new platform for renewable assets it’s always a challenge to deal with the legacy,” says Jacqueline Huynh, asset manager at Allianz Global Investors.

The cost of integration can be a serious barrier to digitalisation, particularly when legacy systems are present in only a small number of plants. Aquila Capital, for example, has opted to leave some of its smaller plants out of its analytics platform because “they are running fine and it will cost too much include them in the system,” says Ahrens.

Another challenge for asset managers is in finding analytics packages that deliver a
wide enough range of functionality. For example, Huynh says: “Because we are a pure financial investor, we don’t need to deal with the assets on a daily basis, but we still want everything. We still want financial reporting, we still want technical reporting, we want to know what happens on site.”

Digitalisation’s future promise
Despite these challenges, most solar asset managers are fully aware of the potential benefits of digitalisation. “Once we have everything on a single platform, once all the data is aggregated, we will be able to perform benchmarking, and this is very important,” Huynh says. “It’s going to allow us to see who our best partners are, who are the best contractors, which are the sites bringing in most revenues. It’s what allows you to make resource allocation.”

Increasing digitalisation will not just deliver much greater O&M and asset management efficiency, but also promises to allow much more detailed analyses of the future state of plants and portfolios. And this insight could be tied to financial forecasts, says Huynh. “You can look at the past, analyse the last 15 years and know exactly what happened and how the asset behaved, and you will be able to look into the future,” she says. Based on past performance and external data, she claims, “you can make predictions with dynamic weather forecasts. You can make predictions based on price curves. You’re going to have dynamic business models and you can have dynamic, updated cashflows.”

These cashflow projections could even offer guidance on investor dividends “this year, next year, in five years and 15 years from now,” Huynh says.

For Schneider, digitalisation is the key to future market growth. “We think if you digitalise your whole process it leads to higher electrical yield, lower operating costs, it creates more confidence in the technology and the transparency leads to more investment and a growing PV market,” he says.

Outlook and conclusions
While the benefits of digitalisation are obvious, and solar is further along the curve than other energy sectors, Schneider cautions that there is still a long way to go. “We are not half the way there,” he says. “I doubt that anyone has the complete process digitalised. The last parts are the hardest ones. We haven’t reached 50% of what’s possible yet.”

Far from being a problem, though, Schneider believes solar’s current state of digitalisation is positive because it highlights that there is still a long way to go in terms of possible cost reduction and efficiency gain. “There’s a lot of potential still,” he says.

Exactly how much potential is impossible to say. However, Schneider points out that studies by McKinsey, the management consultancy, have shown that data-driven companies are 19 times more likely to be profitable than those that do not make the most of the data they have. “Digitalisation is a big challenge on one hand, but it’s also a big opportunity,” says Schneider.

Clearly, digitalisation is set to play a key role as solar enters an unprecedented phase of growth. Between now and 2023, the International Energy Agency forecasts solar will expand by almost 600 GW, more than all other renewable energy technologies combined [3].

References
The references for this article can be found with the online version at https://wp.me/p5dDng-1etQ
Contact Luke Brett, New Energy Update, luke@newenergyupdate.com
Uzbekistan awards first PPP for utility-scale solar project

Uzbekistan will soon add 100 MW clean, renewable energy to its mix through its first solar public-private partnership (PPP), tendered under the Scaling Solar programme. Shukhrat Vafaev, the deputy minister of investment and foreign trade, announced that Masdar Clean Energy of the UAE has won the programme’s competitive auction to develop a utility-scale solar plant located in the Navoi region in central Uzbekistan. Masdar’s bid is just 2.7 US c/kWh. The project is part of an effort by the government of Uzbekistan to develop up to 5 GW of solar power by 2030 to diversify the country’s energy mix. The project is being implemented with support from the Austrian ministry of finance and Switzerland’s state secretariat for economic affairs (SECO), as well as the government of the Netherlands. The government of Uzbekistan announced it will soon tender for an additional 400 MW of solar power, followed by one more PPP for 500 MW.

Contact Scaling Solar, scalingsolar@ifc.org

Updated inverters and optimisers on the cards

SolarEdge is previewing a new version of its 120 kW three-phase inverter with synergy technology which is designed to enable quick and easy installation and inventory management. The company will also launch a new commercial power optimiser with two MPP trackers which connects to up to four modules. The new commercial inverter and power optimiser are expected to be available in the beginning of 2020. The new inverter will use HD-Wave technology and have a new backup interface. It is capable of being connected to backup generators or up to three inverters, each DC coupled to two batteries. The company will also launch a new backup interface which would raise available backup power and eliminates pre-defining loads for simplified energy management. The new offerings are expected to be available in Q4 of 2019. New residential and commercial batteries and smart energy solutions are to be released in the first half of 2020.

Contact SolarEdge, info@solaredge.com

Large wind-power order won

Vestas has secured an order for a 168 MW wind park in Mexico. The order derives from a corporate power purchase agreement (PPA) and includes the supply and installation of 42 wind turbines of the 4 MW platform with V150 rotors. The order also includes service agreement for the operation and maintenance of the wind park over the next five years. The 73 m long blades of the 150 m rotors will be locally manufactured in the TPI Composites factory in Matamoros, which provides the company with blades for the increasing number of V136 and V150 orders the company is receiving in Mexico and Latin America. The turbine towers will also be produced by local suppliers. The company pioneered the Mexican wind energy market when it installed the first commercial wind turbine in 1994. Since then, it has accumulated over 2,3 GW of installed capacity or under construction in the country.

Contact Andrés Domínguez, Vestas Mediterranean, andms@vestas.com

Energy company and tech group team up

The technology group Wärtsilä and Norsepower, a leading provider of low maintenance, software operated, data verified auxiliary wind propulsion systems, have signed a service cooperation agreement. This will enable Norsepower to order service work from Wärtsilä, while Wärtsilä can pursue and sell Norsepower rotor sail projects with support from Norsepower. The agreement was signed in Q3 2019. With the growth of Norsepower’s manufacturing capacity and the anticipated increasing demand for its rotor sails, the collaboration will help the organisation work at scale and further strengthen its customer service offering in cooperation with Wärtsilä’s global service network. The main target sectors include tankers, passenger ferries and cruise ships, as well as dry cargo vessels. Since being launched in 2014, Norsepower rotor sail projects have been installed on three vessels, resulting in a reduction of their CO₂ output by an estimated 5000 tonnes. A fourth installation is already planned for 2020.

Contact Wayne Glossop, Wärtsilä, Tel 082 040 4778, wayne.glossop@wartsila.com
**Protecting patent infringement**

SolarEdge Technologies announced recently that it has filed three lawsuits for patent infringement against Huawei Technologies, a Chinese company. The company is considering filing additional actions to protect its patents. The lawsuits, filed in the regional courts of Jinan and Shenzhen in China, cite unauthorised use of patented technology, which is prohibited by law, and are intended to protect the company’s significant investment in its innovative DC optimised inverter technology. Seeking damages and an injunction, the lawsuits are intended to prevent the defendants from selling any products infringing upon the company’s patented PV inverter and power optimiser technology. The recently filed lawsuits follow the filing of three other lawsuits in Germany in June and July 2018 against Huawei Technologies, a Chinese entity, Huawei Technologies Düsseldorf, a German entity, and Warkraft Solar, a German distributor relating to three patents. SolarEdge holds 303 awarded patents and 240 additional patent applications worldwide.

Contact SolarEdge, info@solaredge.com

---

**World’s largest solar-power water plant**

The water desalination experts Rawafid Industrial and Advanced Water Technology (AWT) have built an ultra-modern plant for extracting drinking water on the coast of the Arabian Gulf in response to demand for a reliable supply of drinking water for a growing population. Sea water is processed here in a two-stage, solar-powered reverse osmosis process to produce fresh water. Some of the key challenges involved in the project included the tight schedule and the capacity of the plant – up to 90 000 m³ of water can be processed here every day. Rawafid Industrial relies on Siemens solutions for the electrical equipment, automation with integrated drive technology, communication, and instrumentation. Efficient use of solar energy significantly reduces the carbon dioxide (CO₂) emissions from the plant compared to plants using electricity from non-renewable sources. In addition to this, the Siemens technology ensures a plant availability of approximately 98%.

Contact Jennifer Naidoo, Siemens, Tel 011 652-2795, jennifer.naidoo@siemens.com

---

**Awarded for smart energy solutions**

Sunfarming was awarded the Innovation Prize for Intelligent Energy Solutions at the Chint Group conference with over 600 participants from 140 countries. Martin Tauschke, co-owner and managing director of the Sunfarming Group, accepted the award. The Global Summit on Market Innovation and Development, hosted by CHINT, China’s leading smart energy solution provider, held in Wenzhou from 9-11 September, focused on “Global Energy, Smart Interconnection”. The event aimed to explore the challenges and opportunities facing the energy sector while providing a platform for the demonstration of new and innovative products. The event attracted scholars from academic institutions, industry experts and leading players from over 140 countries, as well as Chint’s business partners across the globe. Participants gathered to discuss and share expertise on industry trends and critical issues. Highlighted discussions include the keynote speeches on the company’s innovations in the Industry 4.0 era, energy storage and solar, smart grid, and smart meter, as well as low voltage fields.

Contact Sunfarming, info@sunfarming.de

---

**CPD-accredited lightning protection courses offered**

Lightning and surge protection specialist Dehn Africa offers CPD-accredited seminars in lightning protection. These are practical seminars for engineers and consultants, and take place as part of the Dehn academy, the company’s training wing. The courses provide successful candidates with two CPD points. The company’s academy was established in 2014 to offer practical knowledge and skills in the fields of lightning protection, surge protection and safety equipment, offering customer-specific seminars as well as this CPD-accredited session. The workshops are both industry and application specific, including training in photovoltaic systems, wind power, petrol stations, LED lighting, the mining industry, hazardous locations, and earthing and bonding. Other training offered by the company includes the IEC/SANS 62305 part 1 – 4 standards, for lightning and surge protection, DEHN’s Red/Line and Yellow/Line surge protection, lightning protection, earthing and safety equipment. Courses are offered via e-learning as well as through classroom training onsite at the company’s premises. The accredited CPD seminars are aimed specifically at electrical engineers and related consultants.

Contact Hano Oelofse, Dehn Africa, Tel 011 704-1487, hano.oelofse@dehn-africa.com
Power electronics for MV distribution networks improve performance

by Mike Rycroft, EE Publishers

The move to larger distributed renewable energy-based systems has led to the connection of medium scale renewable energy (RE) generating systems in the MV network, with consequent effects on network operation and stability. Network reconfiguration is a common solution, but the emerging use of power electronic devices promises to solve most problems.

Medium voltage (MV) distribution networks are usually operated in a radial configuration as shown in Fig. 1. As a part of network reconfiguration programmes to lessen problems associated with radial feeders, normally open points (NOPs) are built in the network, connecting adjacent feeders, to provide alternative routes of electricity supply in case of planned or unplanned power outages [4], and to allow network balancing.

This allows the use of simple and inexpensive protection schemes as well as providing fast fault isolation to limit the propagation of network faults. However, there is still a possibility of power flow being unbalanced between radial feeders due to different loading conditions, especially when a high penetration of intermittent distributed generation (DG) and flexible demand is present in the distribution networks. This, in turn, leads to high power losses, increased peak currents and undesirable voltage excursions [1].

NOPs provide the advantages of a meshed network, but have the drawbacks of not being able to control power flow between arms of the network, as they can merely be switched in and out of circuit.

MV distribution networks, to which DG are connected directly (e.g., wind farms) or through the aggregation of installations in low voltage networks (e.g., residential-scale solar photovoltaic (PV) systems), are facing technical challenges in areas where clusters of DG exist. Voltage excursions and thermal overloading are among the dominant issues that limit the ability of MV networks to host large volumes of DG [1].

Three technical factors that can limit the capacity of a distributed generation project are fault level, thermal limits and voltage limits. When a generator is connected to an 11 kV feeder, its active power export reduces the power flow from the primary substation and so reduces the voltage drop along the feeder. If the generator power export is larger than the feeder load, power flows from the generator to the primary substation and this causes a voltage rise between the primary substation and generator. Present network design practice is to limit the generator capacity to the level at which the upper voltage limit is not exceeded with maximum generation and minimum load [5].

A further problem is the variable nature of DER systems, which can give rise to
A rapid increase or decrease of voltage on the feeder with high penetration. Electromagnetic devices cannot respond fast enough to sudden changes. Traditional reinforcement with higher capacity lines and substation transformers or shorter feeders from substations placed at higher density points could resolve these problems but at great expense. Active control of power flows and bus voltages through medium-voltage (11 kV) distribution-level power electronics (PE) is an alternative to infrastructure upgrades [3].

Electromagnetic devices cannot respond fast enough to sudden changes. Traditional reinforcement with higher capacity lines and substation transformers or shorter feeders from substations placed at higher density points could resolve these problems but at great expense. Active control of power flows and bus voltages through medium-voltage (11 kV) distribution-level power electronics (PE) is an alternative to infrastructure upgrades [3].

A wealth of information exists on the use of PE for the support of the transmission (high-voltage) grid. These devices are sometimes referred to as flexible ac transmission systems (FACTS) or custom power. From these transmission network examples, many analogies can be made with the application to distribution networks [3]. Applications of power electronic devices such as electronic on-load tap changers, solid state fault current limiters and normally open soft points (NOSP) are mainly under investigation. This article focuses on NOSPs used in medium voltage distribution networks.

**Normaly open soft points**

The NOSP is a power electronic device installed in place of a normally open or normally closed point in a distribution network. Unlike conventional switches, the power flow through a NOSP is not controlled through open and close operation of mechanical contactors, but by controlled firing of power electronic switches. The desired steady state operation is achieved by regulating the real \( P \) and reactive \( Q \) power flowing through the NOSP terminals [3].

Placing NOSPs in a distribution network creates a hybrid structure merging the benefits offered by radial and meshed systems and mitigating any drawbacks. For example, support to an isolated load on a feeder can be provided immediately by means of power transfer from the neighbouring feeder as in a meshed system, while disturbances and faults on one feeder are isolated from the other feeder as with a radial system. One big advantage of an MV SOP is that its back-to-back configuration enables the precise and dynamic control of bi-directional real power flows between two networks [5].

The most common configuration used for NOSPs is the back to back voltage source converter. Fig. 2 shows a typical configuration for a two point connection while Fig. 3 shows a multipoint connection with a common DC bus. The main advantage of this configuration is that the connection between the arms of the network is via a DC link, so there is no problem with accommodating phase differences between the arms at the connection point.

In a general case, multiple feeders can be connected through a NOSP composed of multiple VSCs sharing the same DC bus (Fig. 3) [1]. An SOP with two- or multi-VSCs introduces additional degrees of flexibility for network operation, and the power flow through the SOP can be adjusted within operating limits.
Operation modes

The SOP works under a control unit which regulates the firing of the transistors. The control unit operation is based on an algorithm that depends on the conditions on the connected arms of the network. Basic diagram of the controller is shown in Fig. 4.

With appropriate control, both VSCs produce their individual voltage waveforms with the desired amplitude and phase angle. This provides full (four-quadrant) control of the active and reactive power at both AC terminals. The reactive powers provided, or absorbed, by the two terminals, i.e. \( Q_1 \), \( Q_2 \), are independent; whilst the active powers, i.e. \( P_1 \) and \( P_2 \), are not independent variables, as the sum of the active powers should be equal to zero (Fig. 6).

With the use of the modular multilevel converter (MMC) technology, the operating loss of a VSC is relatively low, approximately 1% per converter [4]. Two control modes are available to operate the back-to-back VSC based NOSP under both normal and abnormal network operating conditions.

Power flow control mode is used to:

- Regulate both active and reactive power flow on the connected feeders under normal network-operating conditions.
- Isolate faults when a fault occurs on one feeder, between the interconnected feeders.

The supply restoration mode can be used under post-fault supply restoration conditions to provide power supply for the isolated loads on one feeder via the other feeder.

Controller operation

Each VSC is equipped with a separate two-level cascaded control system, which includes an outer (power) and an inner (current) control loop. The outer loop uses PI controllers to regulate active power (\( P \)) or DC voltage (VDC) through the direct axis variable and reactive power (\( Q \)) or AC voltage (E) through the quadrature axis variable. The outer loop produces the direct axis (\( i_{d\text{Ref}} \)) and the quadrature axis (\( i_{q\text{Ref}} \)) current reference signals for the inner loop.

The mode of operation is selected between the active power control (APC) and the direct voltage control (DVC) through a switch. Similarly, the reactive power control (RPC) or the alternating voltage control (AVC) is selectable through another switch. Therefore, the NOSP control modes are switchable between the Power flow control mode and restoration modes. The inner loop is used to regulate the values of the current references \( i_{d\text{Ref}} \) and \( i_{q\text{Ref}} \) received from the outer loop. The inner loop PI controller outputs produce the direct and quadrature axis voltage references, \( V_{d\text{Ref}} \) and \( V_{q\text{Ref}} \) respectively. The voltage reference signals are then used to generate the converter terminal voltage (\( V_a, V_b, V_c \)) through an inverse Park’s transformation. The PLL is important for the connection of VSCs to the AC network in order to synchronise the output VSC voltage with the AC network voltage.
When loads connected to one VSC of an SOP are isolated, the frequency and voltage of this VSC are no longer dictated by the grid. Using the current control strategy will cause voltage and/or frequency excursions that may lead to unacceptable operating conditions. In such a case, the VSC connected to the isolated loads acts as a voltage source to provide a desired load voltage with stable frequency. The other VSC still acts as a current source operating with the VDC/-Q control scheme. For voltage control, the VSC output voltage is controlled directly in the d–q synchronous frame by holding $V_q$ to zero.

Optimisation formulation [1]
The operating strategy must have a goal. Three optimisation formulations are considered, each with a different objective. For each optimisation formulation, the voltage angle and magnitude at each node are taken into account and the active and reactive power provided by the two VSCs are taken as decision variables.

Voltage profile improvement (VPI)
When improving the voltage profile of the network is desired, the objective is to minimise the difference between the node voltages and the target node voltage for the network. This objective leads to an optimal dispatch of the SOP’s active and reactive power values to bring all nodal voltages as close as possible to the target value.

Line utilisation balancing (LUB)
When the line utilisation of the network is to be balanced, the objective is to minimise the difference between actual and rated current in each branch. This objective leads to an optimal dispatch of the SOP’s active and reactive power values to achieve balancing of line utilisation.

Energy loss minimisation (ELM)
When the energy losses of the network are to be minimised, the objective is to minimise the loss in the network. Losses comprise transformer losses and resistive line losses. This objective function leads to an optimal dispatch of the SOP’s active and reactive power values to achieve the lowest line and transformer energy losses.

Effect of SOPs on network performance
Numerous studies have been undertaken on this topic, and all have shown that it is possible to improve network performance using SOPs. For example, references [5, 6] gives the results, shown in Fig. 8, of including SOPs in a network.

Accomodating distributed generation
The dynamic nature of SOP operation makes it possible to increase the penetration of DG in a distribution network. The output of DGs is inherently variable and balancing the network voltages and currents requires a dynamic system. Studies have shown that it is possible to increase the amount of DG in a distributed network by using SOPs.

References
[4] “Taking the experience from flexible AC transmission systems to flexible AC distribution systems”.
How to improve electrical network reliability

Information from Noja Power

For an electricity distribution utility, the core directive and core revenue stream is the supply of electricity to end customers. Any interruption to that stream of energy causes an economic loss to the utility. Not only does the interruption hurt a utility customer’s meter readings, but regulators apply their own fines and incentives for utilities to improve their reliability.

In much of the world, the only economically viable method for electrifying vast swathes of the countryside is overhead distribution, which is inevitably more subject to reliability issues. Thus, the omnipresent question arises, “How do I improve the reliability of my distribution network?”

Fortunately, this question has largely been answered, with field results speaking for themselves. The key for the utility engineer is to understand what the optimum investment will be to reach the reliability goals. As is often the case, it is not investing in the latest utility buzzword (smart grid, IEC 61850 or cybersecure SCADA) that will give you the greatest network performance improvements – these technologies have their place, but it is the prudent application of reliability technologies that will build your network performance and revenue, allowing for further intelligent investment of your returns to chase the final 20% of reliability the aforementioned buzzwords address.

Before we cover the technologies, let’s have a quick review of reliability targets. Whilst they are known by many names, the most common metrics are MAIFI (momentary average interruption frequency index), SAIFI (system average interruption frequency index) and SAIDI (system average interruption duration index). Around the world, KPIs for utilities are based on these parameters, against which a utility is evaluated then rewarded or punished commensurate with performance.

As a general guiding principle, most service target performance incentive schemes (STPIS) allow for some momentary interruptions, but the longer the interruption the bigger the punishment. Often there are exclusions for a reasonable level of momentary interruptions, which gives room for key reliability technologies to operate.

Let’s assume a worst-case scenario as our starting point:

- Radial feeders.
- Bare overhead conductors.
- No pole-mounted switchgear.
- A substation circuit breaker for the full feeder (or multiple feeders).

Firstly, 80% of distribution feeder faults are transient. That is, they will cause a momentary fault, then disappear. Faults such as trees blowing up against lines, animals contacting lines, or conductor clashes in a high wind generally occur momentarily.

However, if a substation circuit breaker is the only reliability device in service, it will detect this fault and trip, turning off the power for everyone, even though 80% of the time it could close again and restore the power. Using this principle of “reclosing” we can achieve a huge reliability improvement, as 80% of faults no longer lead to permanent outages.

Fig. 1: Pole-mounted recloser.

Fig. 2: Estimated reliability impact by network technology method.
This reclosing behaviour could be programmed into the substation circuit breaker, so that the substation breaker automatically recloses. This would restore power 80% of the time, improving reliability. It’s a great first step, but all the feeders leaving the substation would have a momentary interruption. Why don’t we add more circuit breakers that act on a smaller zone, and apply the same reclosing principle?

And so, we have the basic reclosing configuration of an overhead distribution network.

This configuration means that only customers directly connected to the faulted zone experience an outage. Most of the customers on this substation would see no issue in a fault, even 50% of the customers on the faulted feeder will see no issues. The reliability gains for this scheme alone vs. the baseline is tremendous.

Of course, the protection engineering required to develop such a reclosing scheme is also very simple. Typically, with a one-second trip time in the substation, a conservative overcurrent grading margin between each subsequent breaker of 250 ms would allow for three or four reclosers along each feeder, cutting the number of affected customers in a fault scenario by huge volumes. Again, following the Pareto principle, 80% of your reliability and detection can be achieved using only simple functions such as overcurrent and earth-fault, leaving the other more complex, esoteric protection functions for the niche cases once you’ve achieved an 80% improvement in reliability.

For even further simple reliability gains where grading becomes an issue, more sectionalisers (automatic non-protection line switches) can be added between reclosers or downstream of devices, allowing for further granular segmentation of the feeder lines.

Once these systems have been implemented, your reliability gains would mitigate 80% of faults, and localise fault reliability impacts largely to the geographic proximity of the fault location. To chase your final 20% on the way to the unattainable reliability perfection, further technologies such as network automation can be used. Fig. 4 shows a great example of reliability gains per technology. While modern reclosing circuit breakers are capable of remarkable protection features, functions and automation, by simply applying autoreclosers to your feeders with correct overcurrent or earth-fault settings and a substation breaker grading well with them, you can achieve massive reliability improvements. In some countries, the company has seen the average interruption come down from six hours to around 15 minutes simply by adding modern reclosers with basic settings to the network.

Contact Jeremy Wood, RWW Engineering, Tel 011 433-8003, jwood@rww.co.za •

Fig. 3: This configuration would result in all customers on the faulted zone experiencing an outage.

Fig. 4: This configuration means that only customers directly connected to the faulted zone experience an outage.
**Simplifying power efficiency testing**

Comtest is pleased to announce the availability of Tektronix’s new software plugin for its AFG31000 arbitrary/function generator, making it possible to perform crucial double pulse testing in less than a minute, and thus saving a significant amount of time when compared to alternative methods. With the new double pulse test software, engineers can quickly define pulse parameters from a single window on the AFG31000’s large touchscreen display and then generate the pulses they need to perform testing — all in under a minute. The application offers impedance adjustment of pulse width and the time gap between each pulse, up to 30 pulses. Pulse widths can range from 20 ns to 150 µs. Double pulse testing is used by researchers and design and test engineers in the power and semiconductor industries to measure and evaluate the switching parameters and dynamic behaviour of power devices, including those made from wide bandgap materials such as silicon carbide (SiC) and gallium nitride (GaN).

Contact Comtest, Tel 010 595-1821, sales@comtest.co.za

---

**Large Chinese order for MV drive systems**

Siemens Large Drives Applications (LDA) has won a contract from Baoshan Iron and Steel (Baosteel), in China, to equip a new steel production complex with medium voltage drive systems. The order for the new hot strip mill in the production plant includes more than 20 Siemens Sinamics SM150 medium voltage frequency converters. This will increase capacity and ensure low-maintenance operation. Commissioning of the drives for the new hot strip mill is scheduled for late 2020/early 2021. Siemens was awarded the contract by Primetals Technologies, a leading global provider of engineering, plant construction and lifecycle services in the metal industry. The new production complex in Zhanjiang, Guangdong Province, comprises three blast furnaces. In total, more than 20 Siemens Sinamics SM150 drive systems will be used in the new plant, for demanding low and high-speed applications with single or multi-motor systems that require high dynamic performance and regenerative capabilities.

Contact Jennifer Naidoo, Siemens, Tel 011 652-2795, jennifer.naidoo@siemens.com

---

**Embedded generation adds value to municipal grids**

Microgrids and distributed energy resources (DERs) represent the grid of the future. So says Schneider Electric’s Poonam Lutchman. Speaking at the recent AMEU Convention in Cape Town, Lutchman said that municipalities need to become autonomous and secure sustainable revenue by getting ready for DER. The integration of DERs into grids makes these grids more complex and dynamic. This calls for changes in the way power systems are planned, operated and analysed. The company has international capabilities coupled with local expertise in this field. It can assist with the complexity of systems and provide technologies. Globally, municipalities are recognising that their conventional business models need to change. One approach is to challenge the “single buyer” model which prevents municipal utilities from buying power directly from private generators. The smart grid concept of decentralised automation and control will allow municipalities to become more responsive, as the network is divided into more manageable sections, she added.

Contact Tracey Ganas, Schneider Electric, Tel 011 245-6400, tracey.ganas@se.com

---

**Local company wins double award in Europe**

Condition monitoring specialists, Wear Check, scooped two awards from top international training body, Mobius, at a condition based maintenance (CBM Europe) conference in Belgium recently. The awards are for first place in the Best Training Partner EUMEA 2018/19 and the Best Student Growth Africa 2018/19. Dennis Swanepoel, the company’s reliability solutions consultant and accredited Mobius trainer, was on hand to receive the trophies. Swanepoel was invited to attend the CBM Europe conference to conduct two full-day reliability solutions workshops: Practical Vibration Analysis and Introduction to vibration, as well as a presentation on Practical High Frequency Modulation. Mobius courses are run by WearCheck and presented either on-site or at the ABB School of Maintenance premises in Johannesburg. Courses include CAT I, II, III and IV as well as the Asset Reliability Practitioner ISO courses, and graduates are awarded CPD points per course completed.

Contact Steven Lumley, Wear Check, Tel 031 700-5460, stevenl@wearcheck.co.za

---
Lessons communities can learn from pilot projects

A three-year European research venture, concluded in mid-2019, assessed what lessons districts, cities and towns can learn from pilot projects already underway. These researchers developed a simulation tool and published their results in a free guide. Germany’s Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) and the European Institute for Energy Research EIFER teamed up with 13 partners from Europe in this multinational study coordinated by the Austrian Institute of Technology (AIT). The European Union funded it as part of the Horizon 2020 research and innovation program. The free English guide and simulation model are available for free at http://reflex-smartgrid.eu. The “ReFlex – Replicability Concept for Flexible Smart Grids” study analysed eight European pilot projects in four countries. Researchers were also tasked to develop a concept for replicating these smart grids at other locales. Rather than reinventing the wheel, municipal governments can draw on these insights to benefit from lessons others have learned.

Contact Claudia Brusdeylins, ZSW, claudia.brusdeylins@zsw-bw.de

Thermal camera streamlines inspections

Flir Systems has announced the Flir T860, the latest addition to its T-Series family. This thermal camera is said to be the first with onboard Inspection Route software for streamlining inspections, including power substation components, distribution lines, manufacturing equipment and facility electrical and mechanical systems. By running a pre-planned route through the camera, the thermal inspector spends less time in the field and faces less hassle when creating survey reports. Featuring the T-series camera platform’s award-winning design, the camera has an ergonomic body, a vibrant LCD touchscreen, and an integrated colour viewfinder for sun glare. The 640×480-resolution thermal camera incorporates the company’s advanced vision processing, including patented MSX and UltraMax image enhancement, provides enhanced image clarity with half the image noise. Pairing the camera with an optional 6° telephoto thermal lens allows the user to inspect energised targets from safe distances.

Contact Reynhard Heymans, Flir, Tel 011 300-5622, reyhard.heymans@flir.com

IPv6 for automatic circuit reclosers

Noja Power has announced the addition of IPv6 protocol capability to its range of automatic circuit reclosers. Driven by field demand for expanding address space in the proliferation of electricity distribution network Internet of Things (IoT) and Intelligent Electronic Devices (IEDs), the company’s RC Series controls are now equipped to handle future networking requirements for these field devices. Available as a firmware update free of charge to users of OSM reclosers, the addition of IPv6 provides added flexibility for communications network design for distribution assets. These reclosers are commonly deployed throughout distribution networks with SCADA communications. Whilst traditional implementations used serial communications for data transfer, the increase in numbers of field devices with communications back to utility control rooms creates a demand for more scalable network topologies which have proven performance in other mission critical applications.

Contact Jermey Wood, RWW Engineering, Tel 011 433-8003, jwood@rww.co.za
Digitalisation and the operation and maintenance of generation plant

by Mike Rycroft, EE Publishers

Growing demands are placed on utilities to meet performance and other requirements. Plant operations must be able to quickly and efficiently respond to constantly changing demand while meeting operational limits. Digitalisation offers the potential to improve control beyond the scope of the digital monitoring and control networks used in power plant today.

Digitalisation has become a “trend”, a buzzword cluttering up the pages of magazines and and overused in presentations. There are many names for this approach, but the common thread is digital. There is some irony involved in this discussion, because power generation utilities were in the first wave of companies using sensors, data collection, and control systems to manage and improve their operations. This is why it would appear at first sight that there is nothing new in digitalisation, as its been used in the power industry for years.”

There is a huge amount of hype and misunderstanding surrounding digitisation, digitalisation and artificial intelligence. Digitisation is the process of changing from analogue to digital without any different-in-kind changes to the process itself. Power system monitoring and control systems are all digital today are they not? The IEC 61850 standard is at an advanced stage of development and adoption, and already incorporates the concept of “virtual components” and “virtual systems”. IEC 61850 based systems are in use in many networks. The smart grid is already well on its way to adoption.

Digitalisation however goes beyond digitisation and can be described as the use of digital technologies to change a process and enhance efficiency and revenue; it is the process of moving to a digital system. Digitalisation embraces more than just collection and use of data in digital form. Digitalisation can already offer a significant range of immediate operational and financial benefits: sensors, devices and software can enable operators to utilise a wide range of data in real-time and improve decision making; control systems enable improved performance and maintenance of vital infrastructure and equipment either on-site or remotely; advanced analytics enable predictive maintenance and simulation to optimise asset performance; remote monitoring and external support can address key human resource and knowledge retention issues.

There is only one physical power grid, but a typical utility can maintain many diverse grid models, each associated with a different enterprise domain, such as planning, operations, asset management, GIS, outage management, and protection. But keeping this data synchronised is a big challenge. Every system works with its own data format, specific details, and has its own team to maintain the data – creating digital data silos. Inconsistencies during data exchange across those systems – or worse, the lack of data exchange – can lead to dramatic consequences like model inaccuracies, suboptimal system performance, possible regulatory violations, and ultimately system-wide blackouts.

The convergence of IT and OT provides the generation industry with greater system integration in terms of automation and optimisation, as well as better visibility of the supply chain and logistics. What makes it distinct is the intersection of information technology (IT) and operational technology (OT). OT refers to the networking of operational processes and industrial control systems (ICSS), including human machine interfaces (HMI), supervisory control and data acquisition (SCADA) systems, distributed control systems (DCSS), and programmable logic controllers (PLCs).

Digitalisation makes use of the number of technologies to achieve an integrated system (Fig. 1).

Communication and interlinking

The Internet of Things (IoT) is another much hyped topic, but a specific application the Industrial Internet of Things (IIoT) is proving to be a game changer in the digitalisation world. IIoT refers to the extension and use of the internet of things (IoT) in industrial sectors and applications. The IIoT has been in existence for years, with a strong focus on machine-to machine (M2M) communication, big data, and machine learning, the IIoT enables industries and enterprises to have better efficiency and reliability in their operations. The IIoT encompasses industrial applications, including robotics, medical devices, and Software-defined processes and opens up a range of applications and potential for optimisation across industries. For electricity, in particular, IIoT applications

![Fig. 1: Use of technologies in digitalisation](image-url)
have been developed to operate and control T&D networks, improve the performance of individual and fleets of power plants, and optimise hybrid microgrid systems.

Deploying intelligent supervisory systems within the existing plant, makes the plant more reliable, more energy efficient more environmental friendly, and a safer place to work. Data can reach every member of staff in the plant for situational awareness. Enhanced situational awareness results in improved up-time and better plant performance.

**Advanced analytics**

Business applications provide the window of interaction to take action on insights, to manage the power plant and generation fleet functions to a greater level of control and to be able to react to changing market, fuel price and weather conditions in rapid fashion. These business applications are designed to increase asset performance, enhance operations, and improve energy trading decisions to create additional revenue and cost reduction opportunities. The applications fall into the following categories:

- **Asset performance management (APM):** This can transform data into actionable intelligence by combining robust analytics with domain expertise, creating a single source of data for all power generation assets across a fleet, utilising predictive analytics to identify issues before they occur, reducing downtime and extending asset life while still balancing maintenance costs with operational risk.

- **Operations optimisation:** This can deliver enterprise data visibility across power plant and fleet-wide footprints, providing understanding of the operational decisions that can expand capabilities and lower production costs.

- **Business optimisation:** This can reduce financial risk and maximise the real potential of the power fleet toward greater profitability with intelligent forecasting for smarter business decisions.

- **Advanced controls/edge computing:** Allows control of power plant operations with advanced technologies. Analytics based solutions manage grid stability, fuel variability, emissions, compliance and other challenges to reduce costs and maximise revenue.

Beyond the control room

The current configuration based on a centralised control room that collects all data from the plant is a complex system already. What can be improved? One possibility is how big data from the remote sites is integrated with the rest of the enterprise to support plant personnel beyond the control room. The speed and accuracy of decision-making is being improved, this leads to actions based on having the right information in the hands of the right expert, no matter where they are. The digital transformation enables companies to exploit technology and expertise better than ever before, but only if the right scalable technology strategy is matched to your business goals.

**The digital twin in power generation**

The digital twin (DT) is a logical development of the digitalisation process. The DT has also suffered from a high degree of hype, mostly associated with animated 3D images of the plant or the system. Yes there are systems that provide 3D images, but the image is not important, what is important is the underlying information and analysis abilities.

Digital twinning is the mapping of physical assets to a digital platform. For the energy industry, this could be a wind farm, nuclear facility or traditional coal plant. The digital replica uses data from physical assets, for instance, the data acquired from the motor of a wind turbine, to analyse its efficiency, condition and real-time status.

The DT is an organised collection of physics-based methods and advanced analytics used to model the present state of every asset of the plant. The DT is used to execute “what if” scenarios and drive outcomes based on analytic models that mirror and predict the functions of the physical assets. The DT twin uses algorithms, system models and artificial intelligence to predict the future performance of the plant. Using the DT twin models and optimisation techniques and control and forecasting, the applications can accurately predict outcomes in the areas of availability, performance, reliability, wear and tear, flexibility, and maintainability.

The specific details of a digital twin will depend on its scale and purpose, but there are two essential characteristics. A digital twin must:
• Always represent an existing operational object: From design proposal to system decommissioning, the digital twin will reflect a specific object.

• Represent the object’s real-world state: Provide data that describes the present and historical condition of the object or process. This information, e.g. engine temperature and speed, may be from user input or sensors, often via the IoT and should be collected over time for further use [3].

Combined, these two characteristics create a virtual representation of a real-world system and its status. It is the ability to determine the state of a specific object that sets a digital twin apart from a simple simulation model. The update frequency for the data to represent the real-world state will vary. A turbine’s state may be updated regularly and frequently, while that of a supply chain, intermittently and asynchronously. As long as the model corresponds to a uniquely identifiable object, and its state is suitably accurate, it can be considered a twin.

The digital twin (DT) is finding its way into the operation and maintenance of power plant. The DT has its predecessor in the SCADA, PLC systems currently used, and the power plant operation and control systems currently used in power plant control rooms. The difference comes with the addition of advanced analysis and simulation abilities, including AI, as well as intercommunication between systems. 3D graphics help to make the system easier to visualise.

The GE digital twin
At its core, the DT consists of sophisticated models or system of models based on deep domain knowledge of specific assets. The DT is relies on having access to a massive amount of design, manufacturing, inspection, repair, online sensor and operational data. It employs a collection of computational physics-based models and advanced analytics to forecast the health and performance of operating assets over their lifetime.

Included in the DT models are all necessary aspects of the physical asset or larger system including thermal, mechanical, electrical, chemical, fluid dynamic, material, lifetime economic and statistical. These models also accurately represent the plant or fleet under a large number of variations related to operation including fuel mix, ambient temperature, air quality, moisture, load, weather forecast models, and market pricing. Using these DT models and optimisation techniques, control, and forecasting applications can more accurately predict outcomes in the areas of availability, performance, reliability, wear and tear, flexibility, and maintainability. The models in conjunction with the sensor data give the ability to predict the plant’s performance, evaluate different scenarios, understand trade-offs, and enhance efficiency.

The GE DT employs AI technologies which leverage data from equipment to generate insights and deeper understanding of operating environments. They include:
- Pattern recognition.
- Learning models.
- Unstructured data analytics.
- Multi-modal data analytics.
- Knowledge networks.

Some of the areas of optimisation possible are:
- Dispatch optimisation.
- Efficiency optimisation.
- Plant startup optimisation.
- Plant life optimisation.

ATOM: Digital twin of Siemens gas turbine fleet operations [3]
The agent-based turbine operations and maintenance (ATOM) model is a digital twin simulation model developed by Decision Lab and Siemens. The digital twin emulates the global maintenance repair and overhaul (MRO) operations of Siemens’ aero derivative gas turbine division. Driven by live data already available within the supply chain, the model provides the capability to use sophisticated simulation and data analytics methodologies to optimise the fleet operations of Siemens, enabling better data-driven decision-making to improve productivity and efficiency in customer operations and asset management.

Decision Lab and Siemens developed the ATOM digital twin which exploits the emergence of digital technologies across Siemens engineering and manufacturing businesses. It uses the vast quantities of data that is available to integrate customers, supply chain, production, and maintenance in order to improve productivity and efficiency in customer operations and asset management.

At its core, ATOM achieves this by modelling the detailed intricacies of customer operations, maintenance facility operations, engine characteristics, and supply-chain logistics across the whole fleet and operational cycle. Representing the entire system, the digital twin provides extensive great analytical capabilities. A core part of the model was made from many independent elements and using agent-based modelling, it was possible to represent the necessary details. To build the model, the developers captured data relating to the following aspects of Siemens gas turbine fleet operations:
- Agent interaction.
- Customer operations (in what conditions, e.g. temperature, customers use the turbines).
- Maintenance facility operations (both main maintenance facilities were considered).
- Engine characteristics (different failure

![Fig. 4: Agent interaction diagram of ATOM [3].](energize - Nov-Dec 2019 - Page 35)
modes associated with particular engine components).
- Supply-chain logistics (as customers are located all over the world).

This is represented in the agent interaction diagram, which defines the complexity of the digital twin environment. In addition to the agent-based modelling approach, the digital twin incorporated a modular architecture, which allowed the system to be divided virtually into its constituent functional layers and provide a system engineering-based approach to model development.

This approach allows concurrent users to interact with the model in different ways, and to use different data sets, and also enable the development team to adopt a continuous development and deployment approach without disruption – a reinforcement learning element is planned.

Future phases of development could include the following:
- A move from an Excel database to a centralised database containing all Siemens systems and databases, for optimised data storage and processing.
- Deploying the model in the cloud, so multiple users can access it.
- Making it possible to use ATOM as a demonstration tool, for work with customers (i.e. to continue improving the visualisation part).
- Adding a reinforcement learning capability to optimise the dynamic decision making process within the simulation environment and present an optimal policy that Siemens might adopt business investment decisions.

References
The references for this article can be found with the online version at https://wp.me/p5dDng-1enF
Send your comments to energize@ee.co.za

---

Fig. 5: Modular architecture of the digital twin [3].
**Adopt renewable-as-baseload strategy**

Wale Yusuff, the managing director of Wärtsilä Nigeria, says it is time to question the suitability of the traditional approach to power generation which has shown its limitations and is no longer suitable to unleash Nigeria’s clean energy potential. The power mix, as currently envisaged in Nigeria’s Vision 2030, with a 30% share of renewable energy as well as a sizable share of thermal-based power, is a robust and appropriate mix for the country. Not only is it more sustainable going forward, but it is also more cost-effective, says the company. Detailed cost analysis has shown that renewables combined with flexible engine-based power plants are more economical than traditional baseload energy solutions, with a total cost of electricity down by 24%. Inflexibility has a cost by limiting how much cheap renewable energy can be economically integrated to the system.

Contact Wayne Glossop, Wärtsilä, Tel 082 040-4778, wayne.glossop@wartsila.com

**Inspecting two 155 m high smokestacks**

The perfect synergy between drone technology and traditional rope access was demonstrated at a recent inspection project undertaken by Skyriders at one of the country’s oldest power stations, located in Mpumalanga. The fast-track project was undertaken in conjunction with partner company Nyeleti Consulting. The two-part project involved the inspection of two 155 m-high smokestacks. The external inspection component was carried out by a two-person team deploying hi-tech drones fitted with high-definition 4K thermal cameras. The thermal imaging was carried out very early in the morning, before the sun’s heat could have an impact on the smokestacks. This was necessary to identify any hotspots that could indicate areas where the internal brick lining of the concrete wind shield had deteriorated.

Contact Mike Zinn, Skyriders, Tel 011 312-1418, mike@ropeaccess.co.za

**Accelerometer for general purpose vibration monitoring**

Instrotech, local representative of Monitran, is promoting their general purpose monitoring sensors, for use with PLCs and other industrial controllers. They provide users with a continuous output of vibration usually as a 4-20 mA signal. Changes in the monitor signal allow the user to spot vibration changes in the part of the machine to which the sensor is attached. The 1185I/C model is ATEX and IECEx Group I and II certified. It has all of the 1185’s components with integral stainless overbraided ETFE cable and is available with a wide range of mountings. The 1185W model is submersible, for harsh underwater environments and areas with constant moisture or condensation. It includes integral heavy duty polyurethane cable, is sealed to IP68, and is available with a wide range of mountings. The 1185IW is ATEX and IECEx Group I and II certified.

Contact Wayne Glossop, Wärtsilä, Tel 082 040-4778, wayne.glossop@wartsila.com

**Portable fuel cleanliness analysis kit**

The Fleetguard FK36000 portable fuel cleanliness analysis kit is a reliable solution for testing fuel cleanliness in the field. Testing can identify dirty fuel, and more importantly the source of the contamination through supply, delivery, storage, handling, and other practices. It also allows for on-site testing of fuel cleanliness, with immediate results. In addition, no power source or batteries are required to perform the test. Most tests use only a litre of fuel, and require five to ten minutes. Results are interpreted immediately, and also relate to the ASTM D2068 FBT number. The Fleetguard FK36000 portable fuel cleanliness analysis kit consists of a hand-operated pump, four fuel cups, a litre fuel container, replacement NanoNet media patches, and a test result interpretation card. NanoNet is an advanced filtration media that traps and retains contaminants, even under real-time vibration and flow surge. The technology leads to greater protection of fuel injection equipment, resulting in extended service intervals of up to 2000 hours, improved engine efficiency and fuel economy, and reduced downtime and maintenance costs.

Contact Deepa Rungasamy, Cummins, Tel 011 589-8512, deepa.rungasamy@cummins.com
Engen safety first campaign for primary schools

Engen’s annual paraffin industrial theatre safety campaign KlevaKidz kicked off in Rustenburg in the North West recently, and will visit ten schools in the area before moving to the Free State and Eastern Cape, concluding in the Western Cape. Over the past ten years, this national safety campaign has reached over 280 000 learners. The campaign again used super hero safety educator, Mr Wise again in the starring role. This educational campaign uses industrial theatre to engage and educate young learners across South Africa about the importance of paraffin safety. The 2019 edition was launched at three schools in October: Nthebe Primary School, Moruleng Village, Machama Primary, Manamakgotheng Village and Segankwana Primary School, Segakwaneng Village and visited ten schools in the Rustenburg area. The educational campaign then travels to the Free State, Eastern Cape, and then concludes in the Western Cape in November.

Contact Gavin Smith, Engen, Tel 021 403-4312, gavin.smith@engenoil.com

Powerful test solution for rotating machines

Omicron’s new CP TD15 combines a high-voltage booster and a high-precision power/dissipation factor measurement module and it generates test voltages of up to 15 kV. The CP CR600 compensating reactor allows users to test rotating machines with high capacitances of up to 1 µF at rated frequency. Together with OMICRON’s CPC 100 multifunctional testing device, the complete 15 kV testing solution can measure electrical parameters, such as insulation capacitance and power/dissipation factor, DC winding resistance and contact resistance. Additionally, the system can also be used for voltage withstand tests and as a high-voltage (HV) source for partial discharge measurements on rotating machines. Additionally, the solution includes the company’s Primary Test Manager (PTM) software which provides users with guidance throughout the entire test procedure as well as automated templates to speed up testing and reduce human errors. The software also enables instant measurement analysis with real-time result graphs as well as automated reporting.

Contact Andre Huddlestone, Alectrix, Tel 021 790-1665, andre@alectrix.co.za

Cooperating in the dismantling of the Fukushima site

Orano has signed a cooperation agreement with the Japanese utility TEPCO concerning the decommissioning of the nuclear facilities at the Fukushima site. Under the terms of the agreement, Orano will share its experience relating to safe and innovative technological solutions for the design, manufacture and operation of buildings dedicated to nuclear waste recovery and conditioning. Activities under the agreement will be led by the group’s teams specialising in dismantling, clean-up and waste management. Orano has been present in Japan for 50 years and works with its electrical utility customers throughout the nuclear fuel cycle.

Contact Stephanie Delon, Orano, investors@orano.group

Company rebrand announced

Diesel Electric Services (DES) has been the official agent for Euro-diesel Dynamic UPS since 11 May 2000. Euro-Diesel recently revealed their new rebranded name KINOLT. Derived from the words KINetic (energy) and vOLT, the new name KINOLT is based on the foundations of the core business: Dynamic UPS. The synergy between Diesel Electric Services and KINOLT is unmistakable. Diesel Electric Services is active in the field of trusted, turnkey power solutions, and is well versed in the understanding the critical power application market. Clients have already recognised the benefits and potential of Dynamic UPS’s especially for medium and high power applications, and the drive towards more sustainable solutions. Battery use in all applications is being challenged. Amongst Diesel Electric Services‘ blue chip clients who are benefiting from the KINOLT Dynamic UPS is The Square Kilometre Array, SA Reserve Bank, Standard Bank, SA Bank Note Company, PRASA, and Ceres.

Contact Diesel Electric Services, Tel 086 110 6633, sales@dieselelectricservices.co.za

Company • Projects • Products • Technology
Choosing a variable frequency drive or soft starter

When accelerating an AC motor to full speed using a full voltage connection, a large inrush current may be required. Additionally, the torque of the AC motor is mostly uncontrolled and can shock the connected equipment, potentially causing damage. Variable frequency drives and reduced voltage soft starters can reduce inrush currents and limit torque thereby protecting expensive equipment and extending the life of the motor and coupling devices.

Choosing between a variable frequency drive and soft starter often depends on the type of application, the mechanical system requirements, and cost (both for initial installation and over the lifecycle of the system).

Soft starters
A reduced voltage soft starter helps protect the motor and connected equipment from damage by controlling the terminal voltage. This limits the initial inrush of current and reduces the mechanical shock associated with motor startup and provides a more gradual ramp up to full speed. Soft starters are also beneficial to electrical systems with limited current capacity when using a soft starter for motor starting to limit the inrush current. By gradually increasing the motor terminal voltage the soft starter produces a more regulated motor acceleration up to full speed. Soft starters are also capable of providing a gradual ramp to stop where sudden stopping may create problems in the connected equipment.

Applications
Soft starters are used in applications where:

- Speed ramping and torque control are desired when starting or stopping.
- High inrush currents associated with starting a large motor need to be limited to avoid supply network issues or penalty charges.
- A gradual controlled starting is needed to avoid torque spikes and tension in the mechanical system associated with normal equipment startup (e.g., conveyors, belt-driven systems, gears, couplings, etc.).
- Avoiding pressure surges or “hammering” in piping systems when fluid changes speed too rapidly.

How does a soft starter work?
Solid state soft starters use semiconductor devices to temporarily reduce the motor terminal voltage. This provides control of the motor current to reduce inrush and limit shaft torque. The control is based on controlling the motor terminal voltage on two or three phases. By limiting the voltage to the motor, a reduced torque is provided to start the load more gradually.

Benefits of choosing a soft starter
Soft starters are often the more economical choice for applications that only require speed and torque control during motor startup. Additionally, they are often the ideal solution for applications where space is a concern, as they usually take up less space than comparable variable frequency drives.

Variable frequency drives
A variable frequency drive (VFD) is a motor control device that protects and controls the speed of an AC induction motor. A VFD can control the speed of the motor during the start and stop cycle, as well as throughout the run cycle. Variable frequency drives are also referred to as adjustable frequency drives (AFD).

Applications
Variable frequency drives are used in applications where:

- Complete speed control is required.
Energy savings is a goal.
Custom control is needed.

How do VFDs work?
Variable frequency drives convert constant frequency and voltage input power to adjustable frequency and voltage source for controlling the speed of AC induction motors. The frequency of the power applied to an AC motor determines the motor speed, based on the following equation:

Benefits of using a variable frequency drive

Performance
- Fully adjustable speed (pumps, conveyors, fans, etc.).
- Controlled starting, stopping, and acceleration.
- Dynamic torque control.
- Provides smooth motion for applications such as elevators and escalators.
- Maintains speed of equipment, making drives ideal for manufacturing equipment and industrial equipment such as mixers, grinders, and crushers.

Versatility
- Self-diagnostics and communications.
- Advanced overload protection.

PLC-like functionality and software programming.
- Digital inputs/outputs (D/I).
- Analog inputs/outputs (A/O).
- Relay outputs.

Energy savings
- Reduces peak energy demand.
- Reduces power when not required.

Energy savings
Variable frequency drives offer the greatest energy savings for fans and pumps. The adjustable flow method changes the flow curve and drastically reduces power requirements. Centrifugal equipment (e.g., fans, pumps, and compressors) follow a general set of speed affinity laws. The affinity laws define the relationship between a set of variables. In this case, the correlation is the pressure change in relation to speed or flow, and the power change in relation to flow.

Based on the affinity laws, flow changes linearly with speed while pressure is proportional to the square of speed or flow. The power required is proportional to the cube of the speed or flow. The latter is most important, because if the motor speed drops, the power drops by the cube.

For this example, a motor is operated at 80% of the rated speed. This value can be inserted into the affinity laws formula to calculate the power at this new speed:

Pump affinity law [1]

Flow volume: \( \frac{q_1}{q_2} = \frac{n_1}{n_2} \)  

where:
- \( q = \) volume of flow
- \( n = \) speed of rotation (rpm)

Head or pressure:

\( \frac{dp_1}{dp_2} = \left( \frac{n_1}{n_2} \right)^2 \)  

where:
- \( dp = \) head or pressure
- \( n = \) rotational speed (rpm)

Power:

\( \frac{P_1}{P_2} = \left( \frac{n_1}{n_2} \right)^3 \)  

where:
- \( P = \) power (W)
- \( n = \) rotational speed (rpm)

From the above, 80%³ or 0,8³ = 51,2%
Therefore, the power required to operate the fan at 80% speed is half the rated power.

Choosing a soft starter or variable frequency drive often depends on your application. Soft starters are smaller and less expensive when compared with variable frequency drives, especially in larger horsepower applications. Larger variable frequency drives take up more space and are usually more expensive than soft starters.

However, while a variable frequency drive can be more expensive initially, they can provide energy savings of up to 50%, therefore providing operating cost savings over the life of the equipment for a lower total cost of ownership.

Reference

Contact Janet Holfeld, Zest Weg, Tel 011 723-6000, jholfeld@zestweg.com ✉

energize - Nov-Dec 2019 - Page 40
Prevention of bearing currents in large inverter driven electrical machines

by Mike Rycroft, EE Publishers

While bearing currents have been around since the advent of electric motors, the incidence of damage they cause has increased with the advent of high switching frequency variable frequency drives (VFDs). Inverters based on fast switching power electronics, such as IGBTs, allow improved operation of variable speed drives, but high switching speed leads to fast rising voltage pulses, that can cause inverter induced bearing currents. These bearing currents may destroy bearings within a short time of operation.

The problem of bearing currents in line frequency driven machines has been known for decades and has largely been solved. Early VFDs used a relatively low switching frequency, but current VFD technology, incorporating insulated gate bipolar transistors (IGBT), creates switching events many times faster than those considered typical in the past. This has led to a rising number of electrical discharge machining (EDM) type bearing failures in AC drive systems, some relatively soon after startup.

Cause of EDM current damage
Damage is caused by arcing between the race and the balls of the bearing due to the breakdown of insulation. Insulating is provided by means of the lubrication grease film. When a sufficiently high voltage is reached across the lubricating film, EDM currents flow on the contact surfaces of the bearing and erode the surface. The contact between the balls and bearing races is intermittent, caused by variations in the lubricant film. This results in the formation of arcs which, in turn, lead to EDM. Capacitive currents flowing across the bearing do not cause EDM, but both capacitive discharge currents and high frequency circulating currents damage the bearings.

Cause of high frequency bearing currents
High frequency bearing currents are a result of current flow in the common mode circuit of the VFD. Common mode currents are the result of the common mode voltage (CMV) and motor capacitance.

Common mode voltage
The common mode voltage (CMV) is the voltage between the common or neutral point of a three phase system and earth. For a balanced sinusoidal wave system the CMV is zero. However, this is not the case with a PWM switched three-phase power supply, where a DC voltage is converted into three phase voltages. Even though the fundamental frequency components of the output voltages are symmetrical and balanced, it is impossible to make the sum of three output voltages instantaneously equal to zero with two possible output levels available. In a PWM VFD system the phase voltage consists of a series of pulses of varying duration but of equal voltage level, and CMV has a pulsed waveform as shown in Fig. 1. The voltage can be equal to the voltage of the pulsed phase waveform.

Voltage overshoot
The waveform shown in Fig. 1 exists at the output of the VFD. Once the motor and cable are connected, a further effect arises, that of voltage pulse overshoot. This causes the voltage at the edge of the pulse to rise above the pulse voltage for a short period , and is mainly due to the inductance of the cable. Fig. 2 shows typical voltage overshoot, which is reflected in the CMV and is a result of the combination of inverter, cable and motor characteristics.

The steep rise and fall times of the CMV cause high frequency current to flow through the motor capacitances to earth. Voltage overshoot compounds the problem by adding high voltage spikes to the CMV which increases the chance of arcing over the bearing.

Motor capacitances
Fig. 3 shows the various capacitances...
in an AC motor which are prevalent when the motor is driven by a VFD. The high $d/dt$ of the common mode voltage applied across the stator and grounded frame of the motor causes pulsed currents to flow through the capacitances shown in Fig. 3.

Capacitances shown are:

- **Stator to frame capacitance (CSF):** This is the capacitance formed between the stator winding and the earthed frame. Most of the common mode current due to the high $d/dt$ of the common mode voltage flows through this path.

- **Stator to rotor capacitance (CSR):** This capacitance is formed between the stator winding and the rotor frame. The value of this capacitance is rather small but is the principal path that charges the rotor body to which the motor shaft is physically connected, and the magnitude of the shaft voltage is dependant on the value of this capacitance.

- **Rotor to frame capacitance (CRF):** The value of this capacitance is typically about ten times that of the stator winding to rotor surface capacitance (CSR). Since the voltage across a capacitor is inversely proportional to its capacitance value, most of the applied CMV appears across CSR and only a small voltage is developed across CRF or the rotor to frame structure.

- **Shaft to frame capacitance or bearing capacitance (CB):** This capacitance is transient and is formed only when the motor rotates. When the motor is stationary or rotating at low speed there is metallic contact across the bearing. When the motor is rotated at or above a certain speed, the balls in a ball-bearing or rollers in a roller-bearing of the motor float and occupy the space in between the inner and outer race of the bearing. An insulating film is formed by the lubricant medium. The value of this capacitance depends on the shaft speed, type of lubricant used, the surface area of the ball or roller in the bearing, the temperature of the lubricant, and the mechanical load on the shaft. The value of this capacitance is important because its characteristics determine bearing current and dictates the life of the bearing.

**Common mode capacitive currents**

These comprise circulating and non-circulating currents.

**Capacitive charge/discharge currents (non-circulating currents)**

Non-circulating currents flow through the machine capacitance to earth. The steep rising and falling edges of the CMV give rise to charging/discharging current through the capacitance of the machine. The voltage across the bearing will depend on the ratio of the capacitances of the machine. Fig. 4 shows the capacitive paths within the machine that determine the bearing voltage.

If the voltage across the bearing reaches the breakdown voltage, current will flow until the voltage drops and the arc extinguishes, to fire again on the next cycle. The current flowing through the bearing to earth will take the form of pulses, rather than a continuous current flow. In a PWM VFD the size and duration of the current pulse will depend on the width of the PWM pulse, and will vary throughout the cycle. Typical current flow paths for currents are shown in Fig. 6.

- **Capacitive bearing currents ($i_1$):** High CMV voltage $d/dt$, in the stator windings causes pulse currents to...
charges up the rotor structure, and finds a way to flow through the shaft into an external earth with a lower impedance.

High frequency circulating currents

Circulating currents flow around the frame of the motor via the shaft, and through the bearing capacitance, and are caused by a voltage developed across the shaft of the motor. This shaft voltage is caused by a high frequency flux field which develops in the core of the stator due to capacitive currents flowing in the stator winding. This flux field couples inductively with the shaft and develops a voltage in the shaft. The motor can, in this case, be thought of as a transformer, where the common mode current flowing in the stator frame acts as a primary and induces the circulating current into the rotor circuit or secondary (Fig. 6).

The frequency range for these circulating currents is in the kHz or MHz range. The size of these currents, and the damage they do, depends on motor size. They first become a problem in motors above 75 kW, and in general, the larger the motor, the greater the damage they cause (Baldour [7]).

In Fig. 6 the circulating current flows along the axis of the rotor, through the bearings and circulates through the stator frame and returns back from the other bearing end.

Influence of motor size

A study by Mutze [2] found a significant difference between the parasitic currents in large and small motors. Very small motors in the 1 kW range show small capacitive common mode currents and larger EDM-currents over the whole speed and temperature range. With larger motors (110 kW range) both circulating and EDM-bearing currents occur, depending on motor speed and bearing temperature, with the circulating currents dominating. With very large motors (500 kW) EDM-bearing currents are dominated by distinctive circulating bearing currents. Aegis [5] agrees somewhat with these findings, concluding that the high frequency circulating currents begin to dominate at motor sizes above 100 kW (Fig. 7).

Mitigation of parasitic currents

Parasitic currents are the result of the combination of motor, VF drive and connected load characteristics. Although
all components are designed and manufactured to perform to specifications, the combination of different components can produce different effects and the specific combination, including connection cables, needs to be taken into account when deciding on mitigation methods. There are three approaches used to mitigate high frequency bearing currents: a proper cabling and earthing system; breaking the bearing current loops; and damping the high frequency common mode current.

Solutions can be classified in two groups:

- Solutions applied on inverter side, and techniques to mitigate bearing currents within the motor.
- The second group includes HF bonding straps, rings, insulated bearings, ceramic or hybrid bearings, insulated couplings, or electrostatically shielded rotor.

**Multi-level converters**

As the converter of the VFD is the primary cause of the problem one of the first points is to consider the VFD itself. Two-level high frequency pulse width inverters for motor drives have problems associated with the high switching rate which produces CMV and high voltage change (d/dt) rates to the motor windings. Multi-level inverters solve these problems by using a much lower frequency switching rate, and smaller voltage steps. Advanced inverter designs can reduce the common mode voltage to a very low value.

**Shielded cables**

Shielded motor cables provide a short, low impedance path for common mode current to return to the inverter. The shield must be continuous and of good conducting material, i.e., copper or aluminium. Using as short a length of cable as possible reduces the inductance and hence voltage overshoot. The VFD should be placed as close as possible to the motor.

**Filters and chokes**

A choke is an inductance fitted between the VFD and the motor. The choke consists of an inductive loop placed around the cables.

There are two basic types of motor filters: Sinewave and d/dt. Both are enhanced versions of chokes, adding more filter stages and other enhancements. The sinewave filter is a low-pass LC filter in each phase of the motor which converts PWM into the corresponding sinewave with approximately the same rms voltage as the original PWM signal. Sinewave filters offer advantages of greatly reduced EMI in all aspects. They also can be retrofitted in existing installations. They cannot be used at lower switched frequencies due to possible internal capacitor damage, and are bulky. Inductive, d/dt filters, which consist of cored coils inserted in the cable feed, “stretch” the rise and fall times of the drive pulses, reducing the high-frequency content of the drive signal which, in turn, reduce capacitive currents through the bearings. These can be installed “after the fact.”

**Bearing protection rings**

(shaft grounding)

EDM and circulating currents are provided with a low impedance path that bypasses the bearing and connects the shaft to the motor frame. Bearing rings can be fitted internally or externally to the motor.

**Insulated bearings**

Insulated bearings the outer race is fitted with an insulating shield to prevent current flowing from the frame to the shaft through the bearing (Fig. 7). Ceramic bearings break the current paths, while the insulating layers of insulated bearings reduce circulating bearing currents and bearing currents due to rotor ground currents.

**Electrostatic shielding**

Gerber [1], de Busse [6] and Baldour [7] found that electrostatic shielding of the motor windings can be effective in reducing inverter induced currents. Shielding creates a grounded conductive path between the stator and the rotor that will bleed off capacitive coupled current. While this technology eliminates stator to rotor coupling, it does not eliminate the potential of coupling from the stator winding to the frame and through the bearing.

**References**


Send your comments to energize@ee.co.za
3D laser scanning services for designing lightning protection

Without physically touching what is being measured, 3D laser scanning creates clear and precise digital records of existing conditions. Laser scanners send out a laser beam that is subsequently reflected off the structure or environment being scanned. The distance and reflectivity of each return signal is measured and recorded, creating a “point cloud”. Hano Oelofse, MD at earthing and lightning protection company Dehn Africa, says this 3D imposition helps to protect plants and other constructions. 3D laser scanning makes it possible to quickly and easily take the exact measurements of complex objects and building structures. With the help of a laser scanner, existing plants and structures can be recorded and digitalised. We are able to offer this service not only for lightning protection systems, but for any building, structure or plant that needs precise drawings of the complete layout.

Contact Hano Oelofse, Dehn Africa, Tel 011 704-1487, hano.oelofse@dehn-africa.com

Supporting rail customers in Africa

One of the most demanding applications for engines is rail operations. With Africa investing significantly in continent-wide transportation networks, this is an area where Cummins’ unique experience, expertise, and technology stand to play a critical role. The original equipment manufacturer (OEM) offers a full line of ratings, with many engine models modified specifically for railway equipment. For example, Cummins railcar engines are based on low-profile designs for use under the car floor. This allows for easy access to service points from underneath the engine, as opposed to inside the passenger compartment. In terms of locomotive power, Cummins offers a comprehensive range of high-performance, low-maintenance diesel engines to meet customer requirements. There are 12 different engines available in a range of ratings, including V12 and V16 configurations. With ratings at up to 2100 rpm, these engines are more fuel-efficient and space-efficient, as well as having longer service intervals and a higher power-to-weight ratio than low-speed units.

Contact Deepa Rungasamy, Cummins, Tel 011 589-8512, deepa.rungasamy@cummins.com

Intrinsically safe electronic pressure gauges

Instrotech offers Keller’s range of five intrinsically safe electronic pressure gauges for use in areas subject to gas explosion risks. The type approvals are compliant with the ATEX Explosion Protection Directive regarding explosive gases. The simplest version, model ECO 1 Ei, offers high resolution and reproducibility for both measuring ranges (-1 to 30 bar and 0 to 300 bar), together with accuracy (typical) of 0,5 %FS and an integrated min/max memory. The application range as per the ATEX directive is defined by identification markings Ex ia IIC T5 or T6. Keller’s type LEO 1 Ei and LEO 2 Ei electronic pressure gauges feature microprocessor-assisted compensation to ensure an extremely narrow total error band (including temperature errors) of only <0,2% FS over the entire range of operating temperatures from 0 to 50°C. Another version of the “Leo” type electronic pressure gauge, the LEO Record Ei, is equipped with an integrated data memory to record pressure and temperature progressions in the measuring medium.

Contact Instrotech, Tel 010 595-1831, sales@instrotech.co.za

Facility now compliant with sourcing regulations

ABB South Africa’s facility in Alrode, Johannesburg, was established in 1981 to produce high-voltage machines, and specialises in manufacturing components for motors and generators to order. The facilities are now fully compliant with the Department of Trade and Industry’s (DTI’s) greater than 70% local sourcing requirement. Featuring a work area of 6000 m², the motors and generators area is equipped with a 15-tonne high-speed balancing machine, cranes with lifting capacities of 80 tonnes, and a load test facility of 13,8 kV, 6 MW. The Alrode facility is also home to a dedicated, coil shop, part of ABB’s commitment to the region, and to modernising local manufacturing facilities in line with the best in the world. The Alrode motor facility is fully compliant with the DTI’s requirements regarding the following components and manufacturing processes, ensuring greater than 70% localisation: casting or frame fabrication; fabrication and stator-core winding; fabrication and rotor-core winding; accessories and assembly, and testing of fully-built units.

Contact Sumaya Abdool, ABB, Tel 010 202-5617, sumaya.abdool@za.abb.com

Intrinsically safe electronic pressure gauges

Instrotech offers Keller’s range of five intrinsically safe electronic pressure gauges for use in areas subject to gas explosion risks. The type approvals are compliant with the ATEX Explosion Protection Directive regarding explosive gases. The simplest version, model ECO 1 Ei, offers high resolution and reproducibility for both measuring ranges (-1 to 30 bar and 0 to 300 bar), together with accuracy (typical) of 0,5 %FS and an integrated min/max memory. The application range as per the ATEX directive is defined by identification markings Ex ia IIC T5 or T6. Keller’s type LEO 1 Ei and LEO 2 Ei electronic pressure gauges feature microprocessor-assisted compensation to ensure an extremely narrow total error band (including temperature errors) of only <0,2% FS over the entire range of operating temperatures from 0 to 50°C. Another version of the “Leo” type electronic pressure gauge, the LEO Record Ei, is equipped with an integrated data memory to record pressure and temperature progressions in the measuring medium.

Contact Instrotech, Tel 010 595-1831, sales@instrotech.co.za
Digital solutions drive mining cost savings

Wabtec has worked with a South African operator to deploy a collision awareness system on a contractor’s fleet at their above ground mining operation. This in itself is not unique as many companies across South Africa are doing the same in order to comply with safety legislation. What’s unique in this case is that the customer is using other solutions within Wabtec’s digital mine portfolio to help solve another problem: ensuring consistent feed grade of ore into the concentrator. In this particular case, downstream processing was impacted due to the varying ore grade quality. Leveraging solutions from the collision awareness portfolio as well as operations performance management technologies help operators blend the ore to get a consistent feed grade into the concentrator downstream. For miners, controlling these sources of variability is ultimately the key to improving throughput and metal recovery.

Contact Wabtec South Africa, Tel 011 974-3813, www.wabtec.com ✦

Supplier of choice in South Africa’s dry docks

The shipping industry’s natural environment of saltwater requires constant and precise corrosion prevention and maintenance. This is according to Craig Swart, the fleet manager at Rand-Air, a hire industry stalwart and provider of compressed air and portable power to a variety of industries – including the maritime sector – for the past 46 years. Proper corrosion control is vital to every vessel’s safety, and its ability to perform at sea. One of the most effective means to remove rust and corrosion from the hull of a ship is through sandblasting. Rand-Air is a longstanding supplier of compressors used for sandblasting in the maritime industry, with fast response times, superior standards of quality and safety, and a depot in close proximity to the docks.

Contact Byrone Thorne, Rand Air, Tel 011 345-0700, byrone.thorne@za.atlascopco.com ✦

Contactless electrical testers take accurate measurements

Traditionally, a metal-to-metal connection has been necessary when probing with test leads or attaching alligator clips to a circuit. Fluke’s FieldSense technology allows the T6 to measure AC voltage, current and frequency without making electrical contact to live voltage. Typically, electricians encounter junction boxes crowded with wires, so finding the right connection point poses a challenge. With the T6-600 or T6-1000, measurements are taken by sliding a single conducting wire into the open fork. Thanks to FieldSense technology, Fluke’s T6 makes work safer as users can measure voltage up to 1000 V AC through its open fork. Having the capability to measure voltage and current at the same time, together with eliminating the need to open covers or remove wire nuts, allows for faster and more efficient measurement taking. In addition, the open fork is the widest available in the industry and can measure wires up to AWG 4/0 (120 mm²) carrying as much as 200 A.

Contact Comtest, Tel 010 595-1821, sales@comtest.co.za ✦

Choose science to halt climate change

The KPMG wind energy report “The socioeconomic impacts of wind energy in the context of the energy transition” highlights significant benefits for society through the delivery of clean energy. The report found that wind energy demand could increase by nine times by 2040 (to 34% from 4%), and by a decade later in 2050 would avoid the same pollution as the 80 most polluting cities (5.6-billion t of CO₂). This reduction would have real benefits for society saving up to four million lives a year and reducing health-related costs by up to 3.2-trillion dollars a year. In response Markus Tacke, CEO of Siemens Gamesa, called on students across the world to opt for studies in STEM (science, technology, engineering and mathematics) and careers in renewable energy to play their part in halting climate change. Students have transformed the climate change debate in 2019, bringing new urgency and energy to the growing crisis.

Contact Jennifer Naidoo, Siemens, Tel 011 652-2795, jennifer.naidoo@siemens.com ✦
People, People, People ...

Seen at the recent Nedbank and EE Publishers "Flexible power generation" seminar

Appointments

Ntombifuthi Ntuli, CEO, SAWEA
Power Electrical Engineering Industry Events

Mining Indaba 2020
Cape Town International Convention Centre
3 – 6 February 2020
The 2020 mining Indaba promises to be bigger than ever. This focused, deal-making event is the place to discuss the most exciting projects with hundreds of leading global investors. It’s your opportunity to build relationships and boost your profile amongst the high-profile investment community.

Contact Simon Ford, info@miningindaba.com

Africa Energy Indaba
Cape Town International Convention Centre
3 – 4 March 2020
Under the theme “From transformation to transition”, the indaba will discuss the digitisation, decentralisation, decarbonisation, democratisation and deregulation of Africa’s energy systems. This will be vital for social and economic development to grow at a pace hitherto only dreamed of.

Contact Thembisa Bambathi, Africa Energy Indaba, info@energyindaba.co.za

Energy Access Investment Forum
Lusaka, Zambia
18 – 19 March 2020
The Alliance for Rural Electrification’s (ARE) will host its sixth Energy Access Investment Forum in Lusaka. The event provides opportunities to discuss major trends in Africa’s off-grid market; for companies to showcase their off-grid solutions, products and services; and for public sector representatives to present upcoming funding and de-risking programmes.

Contact Alliance for Rural Electrification, are@ruralelec.org

Power and Electricity World Africa
Sandton Convention Centre
31 – 1 April 2020
This event is about innovation, investment and infrastructure – energy for the people! The show is intentionally designed to inspire and encourage knowledge exchange, project opportunities and to showcase disruptors who promise solutions that are transforming how we generate and supply energy in Africa.

Contact Brian Shabangu, Terrapinn, Tel 011 516-4015, brian.shabangu@terrapinn.com

Africa Utility Week
Cape Town
12 - 14 May 2020
African Utility Week, a three-day trade exhibition and conference, incorporating PowerGen Africa, gathers the largest group of power, energy and water professionals in the African market. The conference will include a plenary keynote, five conference tracks and five free-to-attend knowledge hubs on the expo floor.

Contact Africa Utility Week, Tel 021 700-3541, auw@spintelligent.com

DUE Conference 2020
Date and venue to be confirmed
Hosted by the Cape Peninsula University of Technology, this conference addresses the needs and technologies associated with the electrification of rural communities to meet the needs of domestic users of electricity in South and southern Africa. More information will be published soon.

Contact DUE Secretariat, CPUT, Tel 021 959-4330, due@cput.ac.za

ADVERTISERS

Advertiser | Page
--- | ---
Alectric | 2
Engen | 36
HV Test | 30
Lead HV | OBC
NewElec | 13
Noja Power | IBC
Reinhausen SA | 19
Technova Power Systems | 19
Scheider Electric | OFC
SDE | 7
Zest | 22

Copyright ©2019 - EE Publishers (Pty) Ltd. All rights reserved.

Copyright of all material appearing in this publication is vested in EE Publishers and the author(s). In submitting any article for publication, the authors confirm that they own the copyright to the said article, which is ceded to EE Publishers for publication. The editor reserves the right to edit or shorten articles submitted for publication. Editing and/or shortening is done with due diligence, where necessary in conjunction with the author(s).

No part of this publication may be reproduced, or stored in a retrieval system, or transmitted in any form, or by any means, except as described below, without the written permission of EE Publishers. Copying of articles in not permitted except for personal and internal use, to the extent permitted by South African law. Permission is not required to make abstracts, on condition that a full reference to the source is shown. Requests for permission for other kinds of copying should be addressed to EE Publishers.

Disclaimer

Articles published in ENERGIZE do not necessarily reflect the views of EE Publishers or the editor. In addition, views expressed by the editor do not necessarily reflect the views of any organisation affiliated to ENERGIZE.

It is a condition of publishing material in ENERGIZE that EE Publishers and the editor shall not be liable for any consequential or other damages arising from the publication in good faith of any article, advertisement, picture, comment, view or opinion. This applies to publishing, failing to publish, late publishing or incorrectly publishing any article, advertisement, insert, picture, caption, etc.

It is acknowledged that errors in transcript, human and technical errors can and do occur, but that reasonable effort will be made to minimise their occurrence, and to acknowledge and correct such errors when they are brought to the attention of EE Publishers.

EE Production
For graphic design and production services...
...we take the load off your shoulders!
Tel: 011 543 7000 | www.ee.co.za
 e-mail: production@ee.co.za
The World's SAFEST RECLOSER

AS USED BY ESKOM

NOJA Power®
VLF cable diagnostics - Improve your cable reliability

mail: info@leadhv.co.za  
Tel: 010 447 3792 | Cell: +27 (0) 83 779 6776

www.leadhv.co.za | www.fb.com/LeadHV