

# wattnow

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THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | FEBRUARY 2021

# WHO WE ARE...



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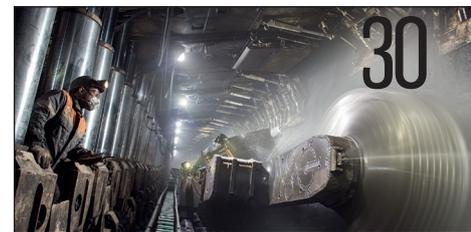
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We are a few weeks away from February, and it seems the industry has woken up. Some of us have been working since the first week of January, and I feel some energy in the air.

I assume most people have adapted to the 'new normal' and have embraced the fact that we will be living with COVID-19 for the near future.

This issue features mining, and we take an in-depth look at how COVID-19 has affected the Mining Industry in South Africa. Our first feature article "How Covid-19 affected artisanal mining" explains how the sector has been affected by lockdowns, unstable commodity prices, and limited healthcare supplies yet, despite these problems, communities have consistently proved highly resilient and as resourceful as ever. We find out more about immediate and lasting impacts. Read it on page [22](#).

Page [26](#) reports on "Top Legal issues for the SA Mining Sector in 2021". 2020 was a year of many risks with countless lessons learnt across the board. The mining sector's critical issues will be on adopting lessons from the successful response to the pandemic and their risk management within their businesses.

Optimising advanced process controls can create significant value for critical industrial processes. Maximising that value requires a comprehensive approach across people, processes, and technologies, read more on page [38](#).

Dudley Basson wrote a very informative article on the "Zeptoseconds Breakthrough" - physicists at Goethe University, Frankfurt, have for the first time studied a process that lies within the realm of zeptoseconds. Read it on page [52](#).

The March issue features Smart Buildings - and the deadline is 5 February. I encourage you to contribute to the **wattnow** - which is for the members - by the members.

Herewith the February issue - enjoy the read!



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# Dear Valuable SAIEE member,

## SAIEE CHARGE REWARD PROGRAMME

Compliments of the new season to you and your family. 2021 is finally here, and we all look forward to a productive and healthy year ahead. As the second wave of Covid-19 continues to proceed unabated, 2021 is set to become another year of keeping safe and healthy by working from home. This, however, does not have to spell doom for your self-empowerment requirements as we are set to continue the trend of providing you with informative webinars to help with your professional development needs. As an added caveat to that, full attendance and participation in these technical engagements earn you as a member Charge Reward Programme points.

The Charge Reward Programme runs in cycles of 5 years. As a member, you have an opportunity period of 5 years (starting from December 2019) to earn these points, after which a new cycle begins, and all unused points are forfeited. Accumulated Charge points can be redeemed on various SAIEE activities like Training Academy courses and membership fees. To find out the amount of Charge point allocated to you, one needs to click on the unique link that was sent out to all members in good standing late December 2020. That link is unique to each member and is not transferable. As a member, you are therefore encouraged to keep your membership in good standing by paying your membership fees for 2021.

Do not forget that now you can pay membership fees in instalments. If your fees are paid in full by the 31st of March 2021, the discounted membership fee is applicable.

As a parting shot, I encourage you to keep safe and earn those Charge Reward Points! Please forward any comments/suggestions to improve to [leanetse@saiee.org.za](mailto:leanetse@saiee.org.za), and let's get the SAIEE working for you!

For more information, on how this programme works, [click here](#). **wn**

Yours faithfully,



Leanetse Matutoane  
Acting CEO

# CHARGE REWARD PROGRAMME



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Alternatively, call Connie on 011 487 3003.



**CHARGE**  
rewards programme



*Mrs Dolly (Doreen) Mokgatle  
Executive Director  
Peotona Group Holdings (Pty) Ltd*

## Peotona boss and empowerment leader Dolly Mokgatle dies

Mrs Mokgatle served as Chief Executive Officer of Spoornet until January 2005. Before that she was MD of the Transmission Group in Eskom where she was the first woman, the first black person and first non-technical person to be appointed to that position.

She was Executive Director of Corporate Affairs; Senior General Manager, Growth of Development and Acting Legal manager after her promotion from a corporate legal consultant.

Before joining Eskom, she was a Litigation Officer of the Black Lawyers Association Legal Education Centre. She focused mainly on political cases, housing, labour and other human rights violation matters.

She previously joined the University of the Witwatersrand as Research Officer with the Centre for Applied Legal Studies and being a Professional Assistant at the Public Interest Law Firm, Cheadle, Thompson and Haysom. In this capacity she worked in General Human Rights, Homeland Removals, Pass Laws, Rural Communities Rights, working closely with Professor John Dugard on cases such as the Moutse Community in Bronkhorstspuit, who took their incorporation into the then Bophuthatswana Homeland territory to Parliament.

Until November 2008, she was actively involved in the restructuring of the Electricity Distribution Industry. She Chaired the Holding Company's Board, which was established and tasked by the Government to oversee, facilitate, and monitor Regional Electricity Distributors' establishment throughout the country.

In 2005 she was involved in National Energy regulation in South Africa (NERSA) as Deputy Chairman of the Board, and Chairman of the Electricity Committee, a position she owned until 2009. She has accumulated extensive experience in the Energy sector over the year, both from a Commercial and Policy point of view.

In October 2012 she was appointed as Chairperson of the State Diamond Trader, Zurich Insurance Company and Total SA.

In February 2015 the Deputy President appointed her as a member of the Advisory Panel on Eskom.

The cause of her death is still to be determined. **wn**

The SAIEE Executive and Council extended its condolences to the family of co-founder and executive director of Peotona Holdings Group, Mrs Dolly Mokgatle, following her sudden death on Saturday 9 January 2021.

We last met with Dolly as a keynote speaker at the SAIEE Women's Day Breakfast in August 2019, where she shared anecdotal stories and inspiring messages to our attendees which left us all in awe. "It is with deep regret that I learned of the passing of Dolly. She was a sterling supporter of our Institute and the keynote speaker at our Women's Day breakfast in 2019. Having worked alongside her in 2015, I will remember her for her knowledge, leadership, wisdom, humble nature and friendship. She was a pioneer in the advancement of women in all spheres" said Sy Gourrah, SAIEE President.

# Rolls-Royce & UK Space Agency launches first study into nuclear power for space exploration

Rolls-Royce has signed an innovative contract with the UK Space Agency for a study into future nuclear power options for space exploration. This first contract between both organisations represents an exciting opportunity to define and shape the nuclear power solutions required in space in the decades to come.

Rolls-Royce is the only company in the world with a singular focus on creating mechanical, electrical and nuclear power solutions that will be essential in tackling the challenges of the future. Space is one such challenging and growing sector in which Rolls-Royce believe power, propulsion and thermal management will play a significant role.

Dave Gordon, UK Senior Vice President, Rolls-Royce Defence, said: "We are excited to be working with the UK Space Agency on this pioneering project to define future nuclear power technologies for space. We believe there is a real niche UK capability in this area and this initiative can build on the strong UK nuclear network and supply chain." "We look forward to developing this and other exciting space projects in the future as we continue to develop the power to protect our planet, secure our world and explore our universe".

Science Minister Amanda Solloway said: "As we build back better from the pandemic, it is partnerships like this between business, industry and government that will help to create jobs and bring forward pioneering innovations that will advance UK spaceflight. "Nuclear power presents transformative possibilities for space exploration and this innovative study with Rolls-Royce could help to propel our next generation of astronauts

into space faster and for longer, significantly increasing our knowledge of the universe."

Rolls-Royce has a rich heritage in nuclear and is well positioned to lead this specific work package to define the future nuclear power solutions for space. The multi-domain applicability of emerging nuclear power solutions will mean the options outlined by Rolls-Royce will also have strong commercial and defence terrestrial use-cases, creating world-leading nuclear power capability for multiple markets and operator needs.

Dr Graham Turnock, Chief Executive of the UK Space Agency, said: "Space nuclear power and propulsion is a game-changing concept that could unlock future deep-space missions that take us to Mars and beyond. "This study will help us understand the exciting potential of atomic-powered spacecraft, and whether this nascent technology could help us travel further and faster through space than ever before."

Innovative power and thermal management alongside novel nuclear technologies, digital capabilities and engineering know-how have considerable application in Space; from the manufacturing and launch of space vehicles, to powering the increasing demand for on-orbit activities, in-situ resource utilisation and exploration. Rolls-Royce has existing, proven capability in these fields as well as significant experience in electrification and the provision of other high-density and sustainable power solutions, which will all support the growing space sector. **wn**

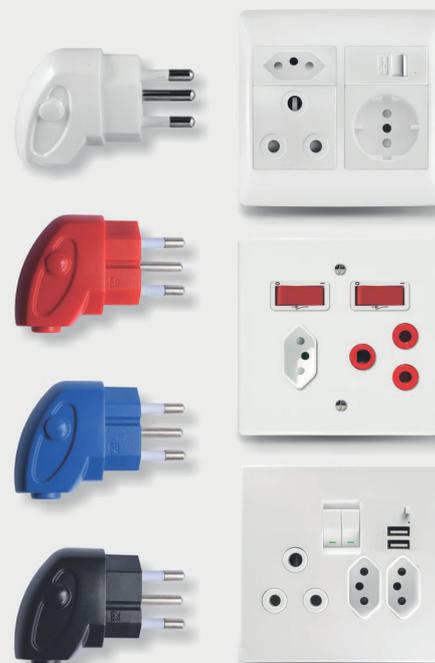
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# INDUSTRY AFFAIRS

## SAIEE Council Member, Refilwe Buthelezi excels



The SAIEE is very proud of our very own council member, Refilwe Buthelezi, for being appointed as Vice President of the ECSA Council.

Refilwe is an experienced chairperson with a demonstrated history of working in the non-profit organisation management industry.

She was awarded the SAIEE Keith Plowden Young Achievers Award for the most outstanding young achiever in 2013 in Electrical/Electronic Engineering. This award follows

from being nominated as one of the “Top 5 Most Promising Women in Engineering” by the University of Johannesburg in 2012. She is currently serving as a Council Member of the South African Institute of Electrical Engineers (SAIEE).

The Engineering Council of South Africa (ECSA) on Tuesday, 08 December 2020, inaugurated their sixth (6th) term Council. The virtual ceremony was officiated by the ECSA Chief Executive Officer (CEO), Mr Siphon Madonsela on behalf of the Department of Public Works and Infrastructure (DPWI) Minister, Ms Patricia de Lille.

The forty-seven (47) member Council comprises individuals from various sectors, including academia, Registered Persons from industry, public and individuals representing the public and private sector.

The new structure elected the President, Mr Mashao Lawrence Lebea and Vice President, Ms Refilwe Buthelezi, who provide a plethora of experience.

The sixth term Council will serve for the next four (4) years effective Friday, 20 November 2020 and will champion the implementation of the 2020-2025 ECSA Strategy founded on the following five programmes:

- Programme 1: Education and Training Standards
- Programme 2: Registration of Candidates and Competent Engineering Professionals
- Programme 3: Assuring Ongoing Professional

Competence

- Programme 4: Professional Practice
- Programme 5: Competent, Efficient and Effective Delivery and Support

### STRUCTURE

Key to this Strategy is the review of the ECSA regulatory instruments to assure a robust regulatory approach, safer infrastructure for the public and closer collaboration with Voluntary Associations.

Moreover, the strategy prioritises the Identification of Engineering Work (IDoEW), where acts explicitly relating to the engineering profession are identified with the scope limits regulating the type, duration and extent of training required to perform such acts and limits of authority imposed on those who do not have the minimum qualifications and experience to perform such acts.

Furthermore, of significance will be ECSA's deliberate efforts to drive gender, race and holistic industry transformation, increase the number of registered engineering practitioners, produce quality leadership of the engineering fraternity, and continue to forge allies with engineering councils globally.

The practical and efficient application of these five programmes by the new Council will reposition ECSA as the industry's voice, reshape ECSA and enhance its importance locally and internationally thereby cementing its role as the effective regulator. **wn**

## Change to the SAIEE Executive



The South African Institute of Electrical Engineers (SAIEE), with the Head Office based in Observatory, Johannesburg has appointed Mr Leanetse Matutoane, the SAIEE Operations Manager, as Acting CEO until further notice.

The SAIEE Chief Executive Officer, Mr Sicelo Xulu, who joined the SAIEE in January 2019, resigned from the SAIEE at the beginning of December 2020.

Mr Matutoane was born in Evaton, on the southern border of the Gauteng province of South Africa. He holds a national diploma in Electrical

Engineering (Heavy Current) from the Vaal University of Technology and an MBA degree from Rhodes University. He has been active in the technical, automotive and engineering consulting operations management industries for a significant part of his career. He has received a Chairman's Award for his role in operations for the HUMMER H3 with General Motors in 2007. Leanetse is a Senior Member of the SAIEE.

The SAIEE Executive, Council and staff wish Mr Xulu best wishes for his future endeavours. **wn**

## New smokestack instrumentation a towering success thanks to Skyriders

When electrical, mechanical and control engineering expert Proconics was recently called upon to install new gas-monitoring instrumentation at a major petrochemical producer, it turned to rope-access specialist Skyriders to provide the secure access and work-at-height required for the trunking, tubing and cabling.

This followed an earlier project whereby Skyriders was called upon for its inspection expertise to assist with the tests needed for remedial work to the smokestack. Marketing Manager Mike Zinn explains that rope access was essential to carry out various concrete inspections and sampling.

An initial drone inspection of the smokestack flagged various areas for close-up inspection by a rope-access team, which resulted in further cracking and spalling being identified. "This is a perfect example of the synergy between drone inspection and rope-access work," comments Zinn.

The testing that had to be carried out included carbonation and cover meter testing and taking core samples for laboratory testing and analysis. In addition, the holes from which the material was removed had to be patched properly.

The testing was essential to determine if the smokestack was structurally sound in order to be able to accommodate the modifications in terms of wind load, among other factors. The inspection data was then handed over for reporting and recommendations.

An expert six-person Skyriders team completed the project in mid-September. A particularly challenging element of the project was that the sampling and subsequent repair work took place at a height of about 20 m to 90 m, and involved equipment such as electric grinders and jackhammers at height. **wn**



## New Leadership Appointments at Schneider Electric for Sustainable Business Growth in Africa

Schneider Electric continues its mission to provide cutting-edge technological solutions to the African continent with the appointment of two esteemed business leaders for the Anglo African region. With one internal and one external appointment, the company is demonstrating its confidence in its existing talent while acknowledging the importance of bringing new expertise and insight into the organisation, ensuring it remains dynamic and ready to respond to market needs.



James Calmeyer, who has led the company's Buildings business since 2017, has moved into a new role as Business Development and Strategy Vice President, for Schneider Electric Anglophone Cluster. In his new position, Calmeyer's main responsibility will be to lead business transformation to accelerate business growth, working in close collaboration with Schneider

Electric teams across Anglo Africa, as well as global teams. Calmeyer will be specifically focusing on commercial transformation, geographical coverage, business intelligence, innovation at the edge, and any process which will add to the company's sustainable and inclusive growth.

"We would like to thank James for successfully leading our Buildings activities during the past three years, implementing a solid set-up and team. He has a strong record of delivering results in a very challenging environment and wish him all the best in his new role," says Albert Fuchet, Cluster President of Schneider Electric Anglophone.



Taking over from Calmeyer, Devan Pillay has joined Schneider Electric and has taken up the position of Buildings Vice President for Schneider Electric Anglophone Cluster, based in Midrand, South Africa. Pillay is an

accomplished business leader with a successful track record in building and growing businesses in different regions including Africa, Europe and North America. He started his career at Eskom (Power Utility) as a Senior Engineer, then joined Schneider Electric South Africa from 1998 to 2003 as Marketing Manager. He has held several leadership roles at companies such as Tyco Energy, GE and 3M, in several countries including South Africa, Turkey, Switzerland and the USA. Prior to re-joining Schneider Electric South Africa, Pillay was the CEO of Signify Commercial (formerly known as Philips Lighting) for Africa.

"We look forward to Devan's contribution to growing our Buildings business in Anglo Africa. His experience showcases his comprehensive knowledge in our industry, and we are confident he will lead this unit to greater heights, applying what he has learnt throughout his esteemed career," says Fuchet.

"These appointments represent a significant investment on our part towards sustainable growth. At Schneider Electric, we understand the value of our human resources as our greatest asset in solving customers' challenges and maintaining business continuity throughout the highs and lows. While we aim to serve our customers, we also strive to provide a dynamic, welcoming and efficient working environment for our team. Congratulations to James and Devan in their new roles," Fuchet concludes. **wn**

# Dust extraction specialist set to exhibit range of construction mobile equipment at Executive Hire Show 2021

Dustcontrol UK is set to exhibit its range of highly effective construction equipment at the much-anticipated Executive Hire Show 2021.

Taking place on Wednesday, April 28th to Thursday, April 29th at the Ricoh Arena, Coventry, the Dustcontrol team will be showcasing the firm's DC Tromb dust extractors, DC 2900 and DC 1800 eco vacuums, and DC Aircube cleaners at stand H31.

The recently remodelled versions of the Tromb range meet modern safety requirements while offering ergonomic and modular functions. One of the major updates is that the new DC TrombTwin model is separable, meaning the dust extractor and pre-separator are easily detached and re-assembled from each other to make transport simple.

Other updates to the range include a simpler filter change system and a motor package that is easier to remove. In addition, improved motors and a sturdier chassis has seen the Tromb family go through a significant expansion and upgrade.

James Miller, Managing Director of

Dustcontrol UK, said: "The Executive Hire Show is always a great exhibition and it promises to be another exciting event in 2021. As with previous events, we'll be demonstrating our popular and high-quality construction mobile equipment, with a focus on their cutting, grinding and cleaning capabilities."

The company, based in Milton Keynes, has over 45 years of experience in developing dust extraction solutions and centralised vacuum systems to fit client requirements in the construction industry. They are experts in capturing dust at its source - both where and when it's created.

Launched in 2007, Executive Hire Show has quickly become the unmissable national exhibition for the tools, equipment and plant hire industry.

The show is a trade-only event open to hire executives throughout the UK and Ireland, while also attracting hire industry visitors from Europe and beyond.

James concluded: "The show will provide us with an excellent opportunity to show the tool hire industry how we can help businesses stay healthy through the use of efficient dust extraction." **wn**



## SAIEE Welcomes new Training Academy Coordinator

The SAIEE welcomes Akhona Mayana as Training Academy Coordinator. Akhona, born and bred in the Eastern Cape, has a thorough learning and development background which spans from academic institutions of higher learning to the financial sector. He obtained a Bachelor of Administration in Human Resources Management followed by a post-graduate degree in Industrial Psychology at the University of Fort Hare. He has good working knowledge in

Human Resources Management and has managed many projects within the Learning and Development portfolio.

"It is an honour and privilege to join an organisational structure of this calibre and nature; therefore, I am looking forward to the new and exciting journey and contributing positively towards the South African Institute of Electrical Engineers critical imperatives for the 2021 financial year," he said. **wn**



# Prof Sunil Maharaj appointed as Chair of Global Engineering Deans Council

The Dean of the University of Pretoria's (UP) Faculty of Engineering, Built Environment & Information Technology (EBIT), Professor Sunil Maharaj, has been appointed the new Chair-Elect of the Global Engineering Deans Council (GEDC). This appointment makes him the first Dean in Africa to occupy this position.

**BY I XOLANI MATHIBELA**

The SAIEE is exceptionally proud of our Office Bearer. Prof Maharaj will be inaugurated as the SAIEE President at the SAIEE Annual General meeting on 25 March 2021.

Prof Maharaj will work as Chair-Elect during 2021 alongside the current Chair, Dean Sirin Tekinay of the American University of Sharjah, and will assume the chairship in November 2021. In this leadership role, he will work closely with leaders throughout the world until the end of 2023. He will work closely with the International Federation of Engineering Education Societies, which links global organisations, professors, students, corporate entities, UN agencies and other multilateral global organisations.

Prof Maharaj says he feels humbled to be entrusted with this position by the members from across the globe who voted for him. "I was on the GEDC Executive Committee for the past two years, which afforded my colleagues time to get to know me, perhaps helping them to vote for me with confidence."

The appointment follows the disappointment of moving the 2020 GEDC world conference, set to be co-hosted by UP in Cape Town – to an online format. "In 2020, for the first time the GEDC and World Engineering Education Conference was to be held

in an African country, but due to the COVID-19 pandemic it was recently hosted online, and I chaired the conference," Prof Maharaj said.

The 2020 GEDC conference theme was centred around "Disruptive Engineering Education amidst Global Challenges". The conference also engaged in how to increase the diversity of people working in engineering. "Getting more women, and especially black women, into the field, is still a challenge. This is a challenge across the globe, not only in South Africa, and there is a big opportunity for women interested in engineering. The cause could be that engineering is perceived as a career designed for men. We – across the globe – need to do more to showcase that this field is for everyone, and develop role models for women who will be instigators for change. And we need to reach out to recruit and welcome women actively. Industries need to play their part as well."

He further notes that there is no need for concern regarding engineering at universities in the developing world. However, there is a need to innovate by continually promoting "disruptive

engineering". "We need always to innovate to stay relevant, and South Africa has done well thus far. It is the only country in sub-Saharan Africa which is part of international accreditation bodies, including being a signatory to the Washington Accord. We are part of the global space, and we are a global player."

The GEDC's vision is to enhance engineering deans' capabilities to transform schools to support societies in a global economy. Its mission is to serve as a worldwide engineering dean network and leverage their collective strengths to advance engineering education and research. The Council's network includes over 500 leaders and stakeholders representing over 40 countries from all continents.

"We are all excited to work with Prof Maharaj, being fully aware of his deep commitment to strengthening not only the role of his university but also that of other African universities," said Dr Hans Hoyer, Executive Secretary of GEDC. "Given his successful record of engaging with the global community, this will link many Deans and universities within our network of



six continents."

Prof Sirin Tekinay, the outgoing GEDC Chair, said, "I am looking forward to a year of working with Prof Maharaj in this capacity and continuing to support him as the immediate past chair beyond 2021.

With the chair's office moving to South Africa, the GEDC will benefit from a whole new perspective that will improve its globalisation. Prof Maharaj

will be the ninth chair of GEDC, and it will be the second time the chair's office is moving to the southern hemisphere in the history of GEDC."

Prof Maharaj says he hopes to facilitate the strengthening of international networks in the organisation, focusing on innovative engineering education and research collaboration through engagement with industry, students organisations, local governments and global funding agencies. **wn**

# Getting the right tools for digitising mines

The astute application of digital tools is the key to continuously improving efficiencies on underground mines, according to Niel McCoy, business line manager for automation and digitalisation at Sandvik Mining and Rock Solutions.

McCoy says that the choice of digital tools needs to be based on each operation's key performance indicators (KPIs). This is because the solutions that are implemented will be focused on monitoring and managing those KPIs. He then recommends a phased approach to introducing digital tools to an operation.

"The starting point is always machine telemetry and basic production or productivity reporting," he says. "From there, the solutions can be expanded."

Sandvik Mining and Rock Solutions has extensive global experience in designing and implementing digital tools, including equipment health monitoring and process management. Its AutoMine® automation offering operates on 59 mining sites globally, while its OptiMine® suite of digital solutions is active on 66 connected sites. The 'My Sandvik' customer

portal, a web-based digital hub, serves 214 sites and its Newtrax technology in wireless IoT connectivity is operating on 115 sites.

"Monitoring equipment health through My Sandvik Digital Services Solutions allows users to draw down telemetry data from their equipment in real time," he says. "The data is automatically compiled into the required report format for quick analysis and response."

The next aspect to be addressed is the actual management of the process being monitored, he says. This is where Sandvik's Task Management and Scheduler – part of its Optimine® suite of digital solutions – can be applied.

"This allows a tablet to be fitted to an item of equipment so that an underground operator can accept tasks and provide real-time progress

reports on those tasks," he says. "The more advanced the equipment, the more data can be extracted and communicated automatically without operator intervention."

The solutions allow for data to be recorded on equipment's key operations – such as the weight of loads in a loader bucket. Telemetry on the equipment gives valuable insights into the equipment's availability and performance – so that management can respond.

"When starting digital journeys, the focus must be on improving current operations," says McCoy. "This means getting work started on time, for instance, before moving onto optimisation efforts. Most digital implementations will battle if the starting point is trying to increase productivity before getting the basics right." **win**



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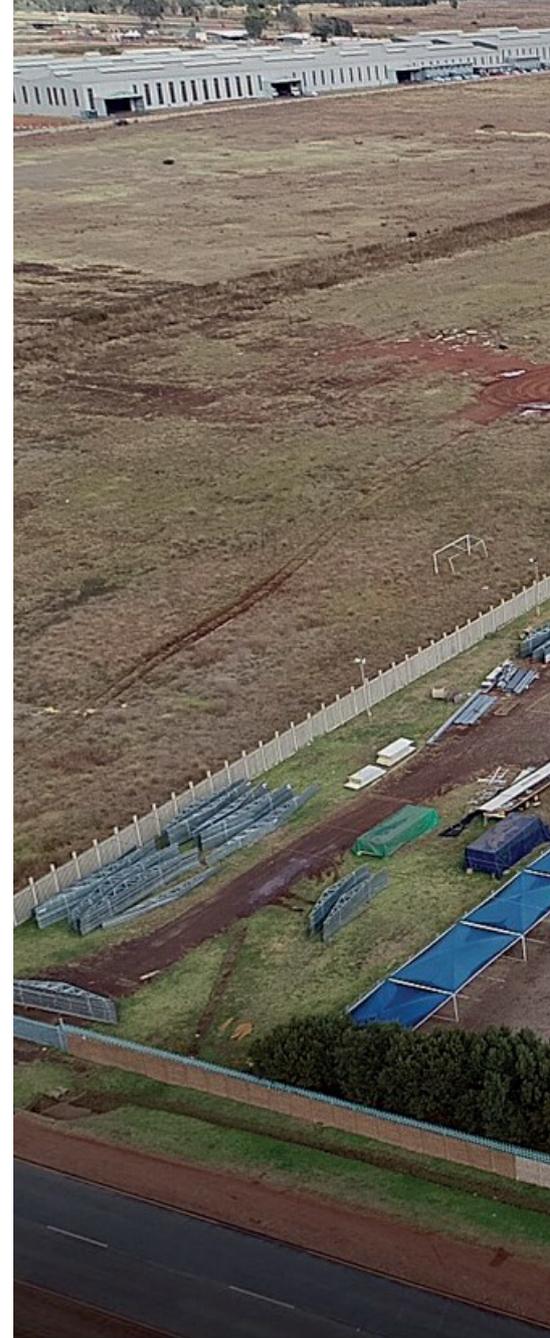
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# ACTOM

Over a 9 month period in the current financial year, Kwikspace executed 630 projects, delivering and erecting more than 1 700 prefabricated, relocatable buildings covering 55 000 m<sup>2</sup>. Of these, over 700 units covering 30 000 m<sup>2</sup> were sold, and the remaining 1 000-plus units covering 25 000 m<sup>2</sup> were rental units, with rental periods varying between one and 24 months.

The units, which included Kwikspace's range of standard sizes and those tailored to exact specifications, were ordered by a variety of industries, with government, commercial, industrial, construction and mining dominant among them. Orders included siting and joining of double wide units and Kwikspace's Kwikspan offering (35 m in length) on site, with many clients requesting extras such as air conditioning, burglar bars, security doors and other requirements suited to their needs.

Applications for which the units were used are across the board, and those required for COVID-19-related purposes receiving priority status. General applications included accommodation, clinics, storerooms, offices, kitchens, canteens, boardrooms, laundry rooms, classrooms, guard houses, training rooms, change houses, locker rooms, toilet facilities, disabled ablution facilities, green rooms and computer rooms. COVID-19 related applications included screening units, isolation units and ICU wards.



"The excess of 1 700 units in this time frame equates to an average of eight units per day working on a five day work week," says Kwikspace Chief Operations Officer Roberto Campos. "This extraordinary production and installation achievement is attributable to Kwikspace's employees' work ethics and commitment to outstanding service delivery."

### COVID-19 SPECIFIC UNITS

Kwikspace provided both rental and purchase units specifically to aid with the COVID-19 requirements and to help with the screening and subsequent



# Kwikspace delivers and installs over 1 700 relocatable buildings in only nine months

hospitalisation of COVID-19-positive patients. Industries and company types benefiting from Kwikspace's fast turnaround time included laboratories, hospitals, education, training, water treatment, supermarket chains, research institutions, gas companies and mining houses.

"The nature of the orders demanded priority, ensuring the fastest turnaround times in our company's history," Campos says. "Among our fastest delivery times were four units for a leading global health and research institute based at Tembisa hospital,

delivered and erected in 24 hours, with other units delivered anywhere from three days to just less than three weeks. The latter included 14 units across three provinces to ensure adequate screening facilities."

To ensure personnel were at minimum risk, Kwikspace provided all necessary personal protective equipment for COVID-19, and installed additional locker rooms and showers to simplify adherence to correct social distancing. "We also instituted a continuity plan and coronavirus monitoring protocol, which were implemented throughout

all Kwikspace branches and facilities countrywide," Campos concludes. Categorised as an essential services provider for the manufacture of COVID-19 required facilities, Kwikspace was permitted to return to business on 4 May 2020. **wn**

# Dry-Type Transformers Ensure Safety at LNG Camp

Dry-type transformers supplied by specialist company Trafo Power Solutions are ensuring the safe and reliable operation of substations in a construction camp at a large Liquefied Natural Gas (LNG) project in northern Mozambique.



*David Claassen, Managing Director  
Trafo Power Solutions*

According to David Claassen, managing director of Trafo Power Solutions, 18 dry-type transformers were included in modular substations built in South Africa and shipped to site recently. The company is in a strategic partnership with leading Italian transformer manufacturer TMC Transformers, and is competing at the highest level with other global OEMs.

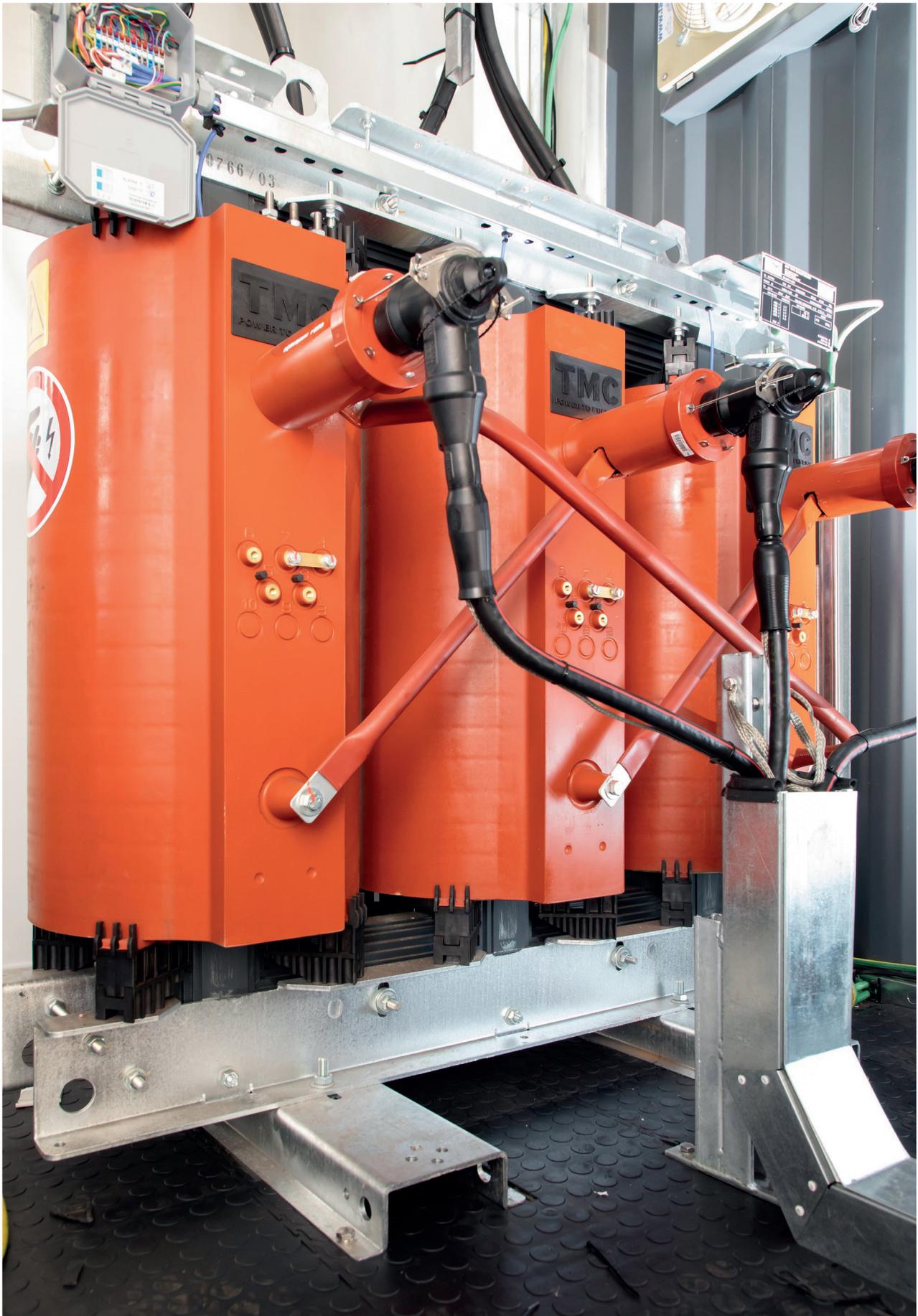
“These substations are for the project’s first construction camp of about 9,500 contractors,” Claassen says. “Our transformers have been specially designed for the high ambient temperatures in northern Mozambique.”

Ranging from 500 kVA to 1250 kVA, the temperature of these units will rise to a maximum of only 80°C when under full load. With Class-H insulation on both the medium voltage (MV) and low voltage (LV) windings, they will withstand a temperature of 180°C. This is considerably more than the potential 40°C ambient temperature in the tropics plus the 80°C temperature rise. The transformers are also designed for levels of humidity up to 95%.

He highlights that the safety advantages of dry-type transformers allow them to be used in this application. As they do not contain oil – which is the usual coolant in conventional transformers – they pose no fire, explosion or environmental hazard.

“A transformer containing oil would present a significant risk in a construction camp accommodating thousands of people in close proximity,” he says. “The safety level of dry-type transformers also means that they can be used in enclosed spaces like modular substations. The minimal maintenance required is an added advantage, being located on such a remote site.”

Claassen notes that the global competition to supply this mammoth project has been intense, and points to the vital partnership between the local knowledge and experience of Trafo Power Solutions, and the technology and expertise of TMC Transformers. **wn**



*1250kVA cast resin transformer installed inside modular substation.*

# How Covid-19 affected artisanal mining

Covid-19 has affected everyone and artisanal and small-scale miners are no exception. In Sub-Saharan Africa, the sector has been affected by lockdowns, unstable commodity prices, and limited healthcare supplies yet, despite these problems, communities have consistently proved highly resilient and as resourceful as ever. We find out more about the immediate and lasting impacts.



As Covid-19 spread across the globe at the beginning of the year, borders and entire countries partially or totally shut down, sending spot prices for commodities crashing. For artisanal and small-scale miners (ASM) in Sub-Saharan Africa, this meant demand for minerals, and in some cases the means to access their production, diminished over an extremely short space of time, as did their access to finance and supply chains.

In most cases this resulted in a complete loss of income for large swathes of communities that have little access to government support.

In turn, pre-existing challenges were exacerbated, with both food insecurity and risks for child labour increasing, though on-the-ground issues have varied widely depending on location and type of operation.

“This obviously had a really serious impact on these communities’ ability to derive a living from mining activity,” says Adam Rolfe, senior manager, good governance, at Levin Sources. “These are marginal communities, so significant shifts in income can affect directly the level of calories they consume, a problem further compounded by breakdowns of

BY | HEIDI VELLA



localised agricultural value chains that in some areas resulted in higher prices for food staples.”

Levin Sources, a consultancy and social venture, conducted small-scale surveys of artisanal miners in Zimbabwe, Mozambique, Uganda, Ethiopia, and the Democratic Republic of Congo in June and July with funding from the World Bank and Gemcorp.

### **IMMEDIATE IMPACTS**

Research by the Artisanal Gold Council has found that, in some instances, stock prices for gold had dropped 40%-50% pre-Covid value, within

a matter of weeks. Even as prices and demand for gold as a financial product increased internationally due to economic uncertainty, a lack of liquidity and a break down in pre-existing formal financial relationships continued to stall the sector. This most likely resulted in increased contraband flows, says Rolfe.

In northern Tanzania, independent research institute IPIS conducted interviews with 37 key informants representing gold, coloured gemstone, diamond, limestone, and salt mining on a rolling basis throughout the pandemic. It found that because there

was no national lockdown, artisanal mineral production continued, though at a reduced pace and price.

“Though most continued to work, there were no international buyers or markets anymore, which meant that miners received very, very, low prices for their minerals. This posed very significant challenges for their communities, which depend heavily on this income,” explains Mieke Thierens, a researcher at IPIS and co-author of the report ‘The impact of Covid-19 on artisanal mining communities in northern Tanzania’.

The report notes that in May 2020, the average price paid for a gram of gold was around 22% less than before the outbreak of Covid-19. Diamond and tanzanite prices seemed affected worse, with reported reductions of 60%–70%.

Similarly, in Shakiso, Ethiopia, an area famed for green gemstones, the crash in global demand for gemstones, as well as strict international travel restrictions, saw the country's mineral exports plummet, according to Levin Sources' research.

## MYRIAD CHALLENGES

Different regions faced different challenges. In Mozambique, government-imposed Covid-19 response measures, such as social distancing, were the main reported cause for decreases in activity. Many mine sites were forced to halve their workforce and some had to shut down completely, with a disproportionate job loss for migrant workers. By the end of Levin Sources' research, nearly 100% of miners reported decreased income.

However, unlike in many other regions, the study found that gold prices at ASM sites in Mozambique remained relatively stable throughout the first months of the pandemic. Miners said they were still selling their gold to the same buyers as before and were not experiencing increased difficulties doing so.

It's thought that this is because the country did not impose restrictions on domestic movement. This allowed the existing system – buyers often playing a dual role as financiers, including in the provision of equipment and supplies such as mercury and food – to continue with limited interruptions.

In Uganda, however, activity decreased significantly due to lockdown measures, resulting in sudden unemployment that, according to the Levin research, seems to have affected women more than men. The disparity is due to a lack of alternative opportunities for women in the region. As mining resumed, an increased presence of children on mine sites, which is prohibited, was reported, as schools were still closed but mines were open.

Rolfe says it is yet to be seen whether the reported increase in child labour is a temporal impact or whether it's a lasting feature of an economy that's been struck and is still healing.

"ASM often plays a pivotal role as a safety net-economy to stop people falling further," says Rolfe.

He adds that if there is more child labour this would pose challenges to responsible sourcing efforts, even though these efforts tend to only account for a small proportion of overall ASM production and trade.

"Child labour is still a problem at artisanal mining sites and responsible industry should explore ways of engaging with the issue and supporting a route out of mining for children."

Resilience against the pandemic  
Speaking of artisanal miners in Tanzania, Thierens says the communities there have proven more resilient than was originally assumed.

"These are very creative communities with complex arrangements for finances and networks and so on. So although it has been very hard on them, the moment international trade became possible again, these communities caught up, they got

better prices for the minerals, and a lot of their suffering and troubles have been, to a point, mitigated in that way," she says.

Coronavirus awareness and health impacts have also proved better than anticipated.

In many cases, governments have tried to raise awareness of the virus, if not much else, and been largely successful. Stories have emerged of communities using their limited resources to support themselves. In Zimbabwe, respondents to a Levin Sources survey reported having collectively funded a Covid-19 ward for miners at a local hospital.

Overall, health-wise, Sub-Saharan Africa appears to have mostly escaped the worst-case scenario expected. Surveys show that coronavirus transmission and health impacts have been minimal.

"The African continent, as far as we know, has been spared from the worst things that were predicted for general health and safety, but of course more awareness would be a good idea," says Thierens.

## THE SITUATION NOW

Lack of liquidity and demand for gold, specifically, is thought to be no longer an issue facing artisanal miners due to a recovery of the stock price globally, according to both Thierens and Rolfe. It's only a continuing problem where local lockdowns are still in place or have been re-imposed.

In some countries, such as in the Democratic Republic of Congo, where Levin Sources has an ongoing programme, spot prices are now even higher than in London. However, Rolfe

warns that this can be associated with issues such as money laundering, with 'gold being used as a currency as opposed to as a mineral'.

While prices are booming for gold, the diamond sector continues on a downward trend.

"For diamonds and other high value gemstones that require significant pre-financing, I think it will really depend on the consumer market. If there is co-location of minerals, there might be limited impacts as miners transition to different forms of mining," says Rolfe.

"But the needs of a population will not suddenly be met overnight by that and we could see significant demographic shifts across borders, or within borders," he adds.

In Tanzania, however, Thierens says that it now appears to be 'business as usual'.

## FORMALISATION

Well established and by now well-known challenges still persist across the artisanal mining sector – including poor working conditions, child labour, and extreme poverty – and to some extent have been exacerbated by the pandemic.

Formalisation efforts must continue but they need also to be incentivised. Rolfe says that formalisation during the pandemic in Sub-Saharan Africa did not always prove advantageous to miners, with licenced miners often unable to work but without access to government support, while in many cases informal mining continued.

"This has resulted in some turning to informal activities once again. And that's the trap," he explains. "There is tension between the formal sector and the path to formalisation, which perhaps doesn't provide as many safeguards or certainties to populations and is not always in-line with the cost

to them, which is ongoing taxation and higher levels of reporting burden."

Despite increased international attention in recent years, there's still so much work to do to improve conditions and end human rights abuses in artisanal mining. At present, responsible sourcing from the sector represents only a fraction of what is produced.

"We need to find a way of bridging the gap between reality and practice; I hope the upcoming European conflict minerals regulations can be a driver for that but I'm not sure it's enough," says Rolfe. "I'd like to see strong policy debate within the OECD about how, after 10 years of discussion on responsible sourcing, three iterations of the due diligence guidance on responsible mineral supply chains from high risk areas, we can now scale the learnings we have acquired." **wn**



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# TOP LEGAL ISSUES FOR THE **SA MINING SECTOR** IN 2021



2020 was a year of many firsts with countless lessons learnt across the board. For the mining sector – key issues for 2021 will be on adopting lessons from the successful response to the pandemic to other aspects of risk management within their businesses; continuing to build a culture of sustainability and managing the risks of environmental pollution.

## Adapting the lessons learnt from Covid-19

Kate Collier, Lize Louw

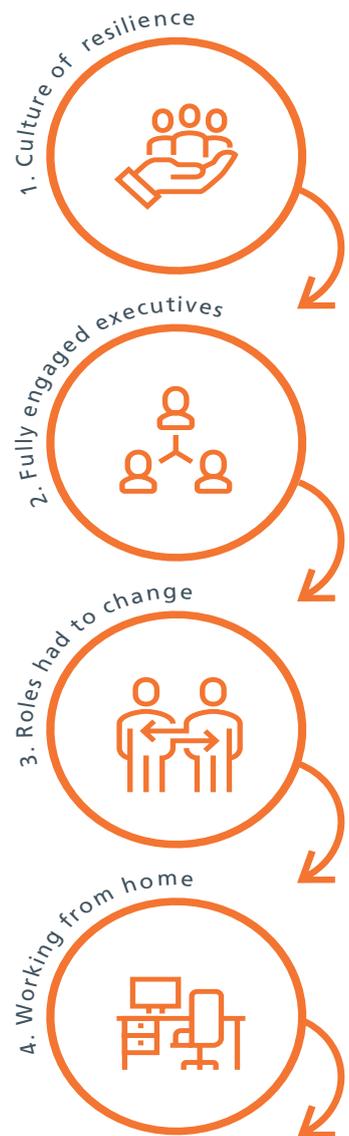
The mining industry's response to Covid-19 in helping employees to cope has largely been lauded.

Although key lessons learnt from the approach to managing the risks posed by the pandemic relate primarily to employee and public health, these can be applied to other areas of business.



## Lessons learnt from Covid-19

- 1.** Organisations that coped best were those which already had a culture of resilience and adaptability and communicated with their employees, making them feel valued.
- 2.** The most effective responses were those led by the most senior executives in a company, and mining companies showed how fully engaged executives were able to bring employees back to work, safely and as soon as permitted and practicable.
- 3.** Key roleplayers and decisionmakers had to identify where their roles had to change and take on new roles, either as the law or their internal risk strategies changed.
- 4.** In future, the lines between work and home will continue to be blurred and the Labour Court has indicated that occupational health cannot necessarily be separated from public health issues.
  1. The understanding of a workplace has to be reimagined and employers should adapt their health and safety policies and systems for different workplaces which now are likely to include private homes
  2. Working from home requires a new approach to managing employee performance, productivity, and defining which categories of employees can work from home.
  3. In mining, there is often a clear distinction between those who can perform their duties from home and those who cannot, but in other sectors there could be a risk of unfair discrimination. Work from home policies must take this into account.



The occupational medical practitioner (OMP), in addition, to issuing all employees with a certificate of fitness before they could work at a mine also had to consider potential vulnerability to employees to a possible future event Will this become a standard for all possible future vulnerabilities, or be limited to COVID-19? This has certain consequences:

1. Employers will have to consider whether and how to terminate employment of vulnerable employees who cannot obtain a certificate of fitness because of possible future health complications. SA labour law allows incapacity as a reason for termination, but traditionally it referred to poor work performance or medical incapacity.

However, there are also broader categories of incapacity (e.g. a driver that loses a driving licence) and the lack of a certificate of fitness falls into this category.

2. Some employers have approached the pension funds to pay disability benefits to those employees who cannot work because they are vulnerable to Covid-19. The response across the board has been “no”. Employer can take the following steps:

- assist employees to file a claim on the basis they cannot work;
- ask the funds to amend their rules;
- engage with the Financial Sector Conduct Authority to issue a circular on how these claims should be processed.

# Building a corporate culture of sustainability

Jonathan Veeran, Paula-Ann Novotny

1. Environmental, Social and Governance (ESG) standards are a set of non-financial performance indicators. Investors typically use them to assess a company's performance from a sustainability and societal impact perspective, in order to inform investment decisions, and companies typically use them to de-risk a project and measure their risk profile for investors.
2. To standardise the ESG narrative, Companies can start by incorporating ESG into their core business model and decision-making. This will assist to set qualitative disclosures and quantitative metrics (KPIs) and report on them transparently.
3. There are various international efforts for uniform ESG standards, eg the SASB (industry-focussed) and TFCED (pillar-focussed).
4. Linking back to the UN's 2030 Sustainable Development Goal Agenda and contributing to the Sustainable Development Goals, we are now in the "Decade of Action" which makes it more imperative for businesses to focus on ESG and which drives the "actionable impact" that the ESG standards have.
5. There are some 400 sustainability reporting instruments in different countries, the majority of which are mandatory. Most recently, in 2019 the European Union passed a law requiring disclosures on sustainable investment and sustainability risks. The European Parliament will be the first supranational regulator that will establish a common set of standards for determining whether an economic activity is environmentally sustainable or not.
6. SA's mining industry is moving in the direction of developing mining-specific standards on ESG to guide monitoring and disclosures, beyond the current independent reporting requirements under current legal frameworks (e.g. Mining Charter, procurement spend, environmental permitting compliance and Social and Labour Plans).



# Building a corporate culture of sustainability



7. **CURRENT TRENDS: Operationalising ESG as a culture:** Companies need to move away from seeing ESG as a reporting and data gathering exercise, to extracting value from it. ESG standards need to inform all business decisions and be understood and believed in by all management, supervisors, employees and business units/ functions.

8. Deloitte's 6 recommendations on sustainable investing, and thus incorporating ESG into operational culture are:

- embrace a commitment to value beyond compliance;
- earn investor trust;
- mainstream shared value and shared responsibility;
- anticipate and influence the regulatory environment;

- unlock value beyond compliance (measuring sustainability performance);
- meet market demands for greater disclosure.

9. Webber Wentzel's Economic Development Plan (EDP) can help mining companies to:

- identify the industry, regulatory, geopolitical and social risks they face
- establish reporting metrics
- identify programs to track performance
- advise on data collection and disclosure
- align ESG functions with board oversight
- integrate these goals into every aspect of the business.

10. The EDP must be done on a company by company basis, making ESG goals easier to implement in practice.



# Environmental pollution has far-reaching consequences

Garyn Rapson, Merlita Kennedy

The number of class actions stemming from environmental pollution events is rising internationally, and especially in Africa and SA.

1. These events need not be current. SA law also covers historic pollution or pollution on land that a company owns or controls. Even if the company was not the perpetrator, it has a duty to address it:
  - Under Section 28 of the National Environmental Management Act
  - Under Section 19 of the National Water Act.
2. Addressing this pollution is very complex and requires technical expertise. However, there is a risk that remedial measures could incur liability in the event of a subsequent class action.
3. We advise a company to:
  - appoint these experts under legal privilege
  - ensure all draft reports are written under legal privilege
  - submit reports to government only in final form.
4. There should be a separate technical team for potential future litigation because the team involved in the cleanup will be conflicted.
5. It is necessary to have a co-ordinated action plan, with technical and communications teams working together.
6. There must be very strict document management procedures (including notes and boardroom minutes) and timeline management.
7. Ignoring these steps could result in administrative directives/compliance notices or even criminal liability, up to board level.

Class actions, multi-party actions or representative actions allow a number of individuals bringing an action against the same party to combine in one lawsuit.

1. It is a two-stage process: certification, where a group approaches a court to be certified as a class, followed by action.
2. SA's class actions currently follow common law but given the increase in frequency there may be developments in legislation.
3. The overarching consideration in certifying a group is to serve the interests of justice. Another important factor is that the main action must be try-able.
4. International examples of environmental class actions include Lungowe vs Vedanta Resources; the Bodo community and others vs Shell Petroleum of Nigeria; Arica victims KB vs Boliden Mineral AB.
5. Local examples of general class actions include De Bruyn vs Steinhoff International; and Nkala and others vs Harmony Gold Mining and others (referred to as the silicosis action). Another class action is looming over black lung disease allegedly contracted by coal miners.
6. SA courts have taken a more liberal approach towards class actions involving members of the public sustaining bodily harm, and a stricter approach in respect of pure economic loss. **wn**



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# The Future of Mining in South Africa

## - Innovation imperative

The burning question for Mining companies globally and in South Africa is how to grow sustainably and deliver a return to their stakeholders.

BY | ANDREW LANE & JÜRGEN BEIER

Local mining companies and internationals with significant local assets manage unique South African operational complexities while still operating in the context of global pressures. We believe a step-change in every respect of the current business is required for survival.

Mining companies face challenges to profitability in the form of unfavourable commodity prices and more stringent mining conditions. While commodity prices have improved since their 2008

lows, prices remain stagnant or falling, limiting mining companies' revenue potential. Declining ore grades at current depths also mean that mining companies have to mine deeper to reach new deposits, significantly increasing the extraction cost.

Since the start of 2000, over 75% of new base metal discoveries have been at depths greater than 300m. Mining at these depths also introduces additional safety issues due to the high risk of rock falls, flooding, gas

discharges, underground earthquakes and ventilation problems.

To an even greater extent than their global counterparts, South African mining companies' margins are under pressure. The combination of stagnant or falling global commodities prices and rising input costs are forcing mining companies to make difficult decisions to sustain short-term operations, while still aligning these decisions with long-term objectives.





In particular, labour and energy costs have exceeded inflation. The annual “strike season” is characterised by ever-increasing demands by unions and mine workers who may not fully appreciate the challenging operating environment that mining companies face. Above the workers’ requirements, there are rising demands by government and civil society as to the role mines should play in society. There is a real need to find new ways to deal with labour as drivers are pushing towards upskilling and mechanisation

to improve the working environment and reduce dependence on large quantities of low-skilled labourers.

The government increasingly expects mining companies to fulfil social needs typically addressed by the government in developed countries, such as providing essential services, education and healthcare. These expectations are often not clearly defined and are compounded by local community demands for employment opportunities, skills

development opportunities, education for their families and modern healthcare facilities. The perception of a lack of (or inadequate) progress in these critical areas is often met with vocal opposition, strikes and unrest. This can significantly impact project development through costly operational delays and reputational damage to mining companies.

There is a need to improve the social dividend in an environment where we employ fewer people due to

upskilling the existing labour force and creating more upstream employment opportunities.

South African mining companies require a deep understanding of shifting community and government expectations and a commitment to a high level of transparency and operational sustainability to address relevant stakeholder groups' demands. While the government has ultimately declared it has no short-term plan to pursue resource nationalisation, resource nationalism is not unique and is here to stay.

### **INNOVATION IS THE NEW KEY TO SURVIVAL. IT'S ABOUT MORE THAN JUST COST CONTROL**

Incremental improvement is no longer enough to sustain this sector. This explains why many leading organisations are rallying behind the innovation imperative.

90% of innovation efforts fail. There are no shortages of ideas, but it's about finding the right ones and delivering a result. Innovation goes beyond technology. There is a myriad of ways and places to innovate. No single innovation will solve the problem on its own - you need to consider the whole system, including the socio-economic system.

It is rapidly becoming clear that innovation can do much more than reducing capital intensity. Approached strategically, it also has the power to reduce people and energy intensity, while increasing mining intensity.

### **CAPTURING THE LEARNINGS**

The key is to think of innovation as much more than research and development (R&D). While exploratory R&D has the power to streamline processes in

the future, innovation revolves around companies' current capacity to adapt practical applications that already exist in other industries and apply them to fit the needs of mining companies today.

For instance, civil engineers' tunnel boring machines to excavate the Chunnel can vastly reduce miners' reliance on explosives. Until recently, those machines were too large to apply in a mining setting. However, some innovators are now incorporating the underlying technology to build smaller machines - effectively adapting mature solutions from other industries to realise more rapid results.

### **RE-IMAGINING THE FUTURE**

At the same time, innovation mandates companies to think in entirely new ways. Traditionally, miners have focused on extracting higher grades and achieving faster throughput by optimising the pit, schedule, product mix and logistics. However, a genuinely innovative mindset will see them adopt an entirely new design paradigm that leverages further information, mining, and energy technologies to maximise value.

For decades, mining companies have understood the imperative to adopt technologies to accelerate automation and reduce fatalities. That explains why leading companies continue to look at new technologies - such as nanomaterials, 3D printing, modular design, robotics, bioengineering, and alternative haulage—to further improve operational performance.

In today's world, however, value is measured on more than these metrics. To improve long-range planning and forecasting, companies must explore emerging information technologies, such as cloud computing, embedded

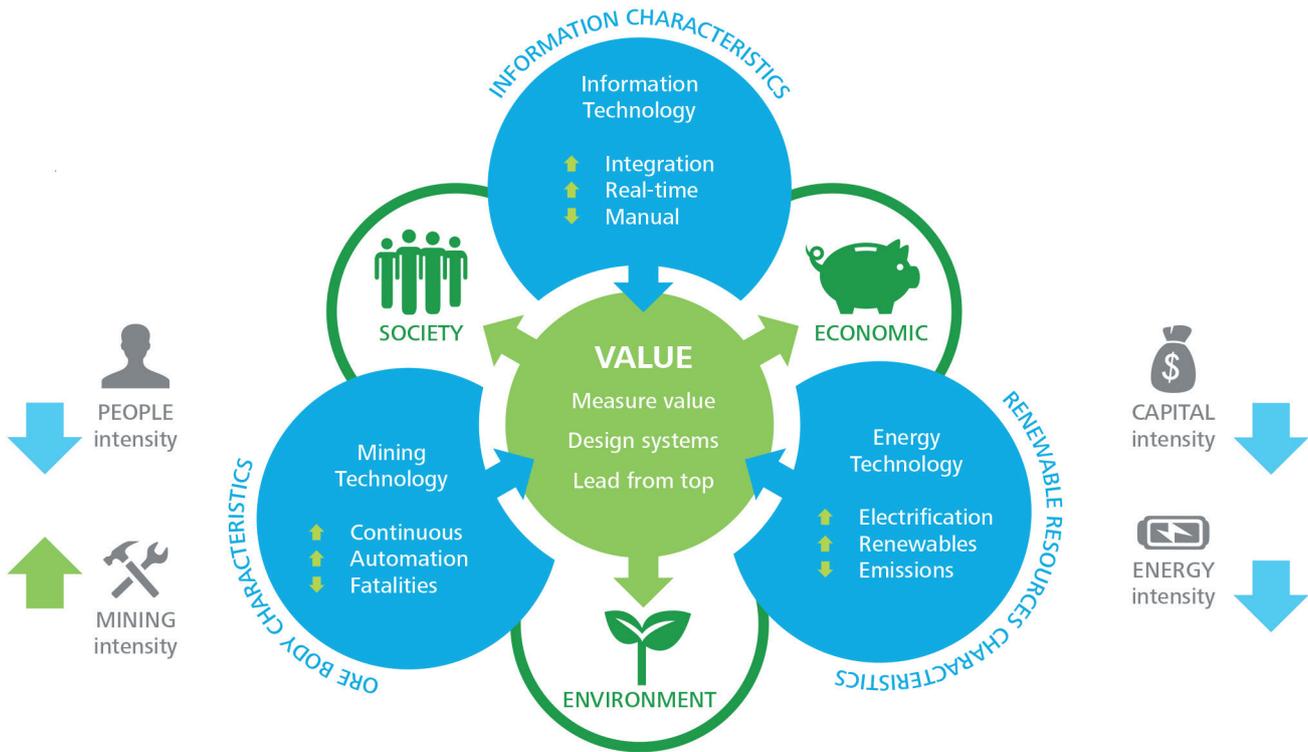
logic, sensors, GPS systems, cybersecurity, big data, simulation modelling and 3D visualisations. To reduce emissions and accelerate electrification, they must also look towards energy technologies such as advanced materials, energy storage, smart grids, renewable energy conversion, superconductivity, non-detonating solutions and high-energy lasers.

By integrating mining, energy and information technology into mine and process design in an innovative way, it is possible to achieve radical performance improvement breakthroughs.

This approach applies to new and operating mines. First, create a lean mine and then enable high performance with information technology.

Integrated system design typically leads to new performance levels that are not possible on an incremental basis. By focusing on maximising value for the environment and society as part of the mine and process design, new value levels to shareholders are created tangibly and sustainably.

These technologies can help companies reduce people, capital and energy intensity while increasing mining intensity. By integrating mining, energy and information technology into mine and process design in an entirely innovative way, miners can achieve radical performance breakthroughs. They can improve safety standards, save money, optimise their energy mix and vastly enhance operational performance. However, to achieve these significant breakthroughs, miners must articulate a bold vision of the future, one that hinges on achieving radical leaps rather than incremental shifts.



*With a system of interconnected components and processes it is often easier, less risky and more profitable to solve many problems at the same time.*

Innovative thinking needs to influence how we engage with workers, government, community and all other stakeholders. New solutions need to be found to improve and prepare us for delivering in a changing employment landscape.

As mining companies begin to apply innovation to their full operational ecosystem, they stand to realise significant gains. Here are some ways to accelerate this process:

**THINK BIG, TEST SMALL AND SCALE FAST**

Because mining companies typically prefer to test new systems at scale, they frequently take a narrow focus to system upgrades to keep costs constrained. Innovators turn this formula on its head by looking at an entire system's components to uncover the most significant opportunities

for structural improvement and then running small tests to establish proof of concept. This allows companies to cost-effectively eliminate operational risk before rapidly scaling to realise substantial gains.

With modular technologies, the advantages conferred by economies of scale disappear, allowing companies to think big, test small and scale fast.

**LEVERAGE EMERGING TECHNOLOGIES**

New technologies hold the promise of vastly altering mining sector fundamentals. 3D visualisation tools can help companies track their people, equipment and changing environment at each mine site, in real-time.

New mineral processing technologies are emerging to reduce the safety hazards associated with gold extraction

and unlock previously uneconomic mineral deposits. Social media helps companies facilitate electronic booking at mine sites and enhance employee access to information, no matter where they're located.

Some companies have even launched SMS messaging platforms to foster two-way communication with employees, solicit feedback and improve workforce engagement.

New production and logistics technologies also promise to reduce both the use of natural resources and emissions. For instance, when up and running, Vale's S11D project's mine and plant in Carajás, Brazil will consume 93% less water, use 77% less fuel and produce 50% less greenhouse gas emissions than a comparable operation using conventional methods.

**BECOME PART OF AN INNOVATION ECOSYSTEM**

Organisations cannot develop an innovation strategy in isolation. To drive actual industry change, miners should consider entering alliances or joint ventures with technology providers and other companies already taking steps to harness organisational intelligence.

By pooling talent, ideas and insights, collaborative organisations heighten the odds of identifying innovation breakthroughs capable of benefiting all industry players.

**PREPARE FOR NEW OPERATIONAL REALITIES**

By fundamentally altering industry realities, innovation often threatens

the status quo. This mandates mining companies to think through its implications in advance. As companies rely increasingly on automation, for instance, they will likely require fewer mine workers.

While this will improve safety, it can also raise community concerns in countries where mining is seen as an employment creator. As such, in the future mining companies must consider other ways to create jobs by using its purchasing power to spread mineral-wealth and provide social benefits across a broader community ecosystem.

**CONCLUSION**

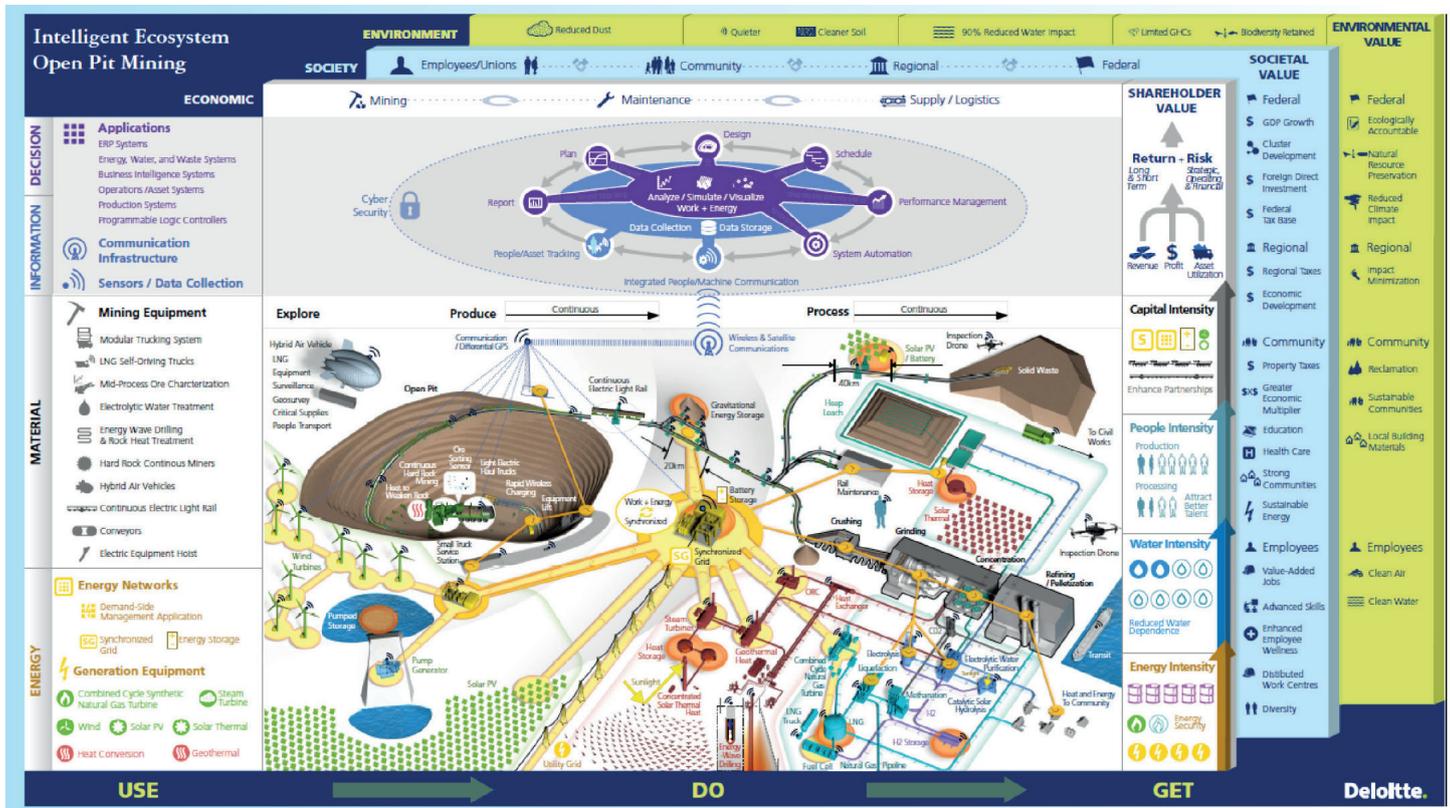
Innovation can drive more than cost reduction. It can help mining companies

mitigate and manage risks, strengthen business models and foster more effective community and government relations. It can help mining services companies enhance their value to the industry by developing new products and services.

Longer-term can even position organisations to move the needle on such endemic issues as corporate social responsibility, environmental performance and sustainability.

Mining companies need to be prepared for divergent future scenarios where collaboration is a crucial component and consider how to move from today's business to business of tomorrow's success. **WN**

© Article courtesy of Deloitte



What could a mine look like in the future?

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# The potential of advanced process controls in energy and materials

Optimising advanced process controls can create significant value for critical industrial processes. Maximising that value requires a comprehensive approach across people, processes, and technologies.

**BY** STEPHAN GÖRNER  
ANDY LUSE, NAMAN MAHESHWARI,  
RAVI MALLADI, LAPO MORI, AND  
ROBERT SAMEK

Industries such as chemicals, metals and mining, oil and gas, and power generation typically require computerised, near-real-time process controls. These basic control systems are often operated manually to adjust for desired target values (known as “set points”) in response to changing conditions, such as temperature, pressure, or incoming feedback. However, nuanced advanced-process-control (APC) systems often result in significantly better performance by automating responses—similar to how cruise control on a car regulates the speed and maximises fuel efficiency.

In recent years, industrial companies have made significant infrastructure investments in APCs but have

extracted only a small fraction of their value. In some cases, less than 10 per cent of installed APCs are activated or optimised. In contrast, others have not been reevaluated to ensure inputs and constraints are properly tuned and solving for the right objective. And those companies that do adjust their APCs sometimes fail to test them sufficiently, or they lack adequate management systems to track and report performance and rely on external vendors for maintenance.

Enabling APCs to operate more efficiently requires a combination of regular tunings and a comprehensive approach that addresses sensors, devices, and control loops and educating and training control-room





operators on the latest techniques. With the recent advances in computing power (and lower computing costs), APCs can be tuned using machine-learning models. Advanced analytics can produce responsive insights from large amounts of historical data, increasing the tuning process's speed and reducing human bias or intervention.

Chief information, technical, and operations officers who take the necessary steps to optimise their APCs in a repeatable, systematic manner can help realise significant gains—including an up to fifteen per cent increase in throughput, a 5 per cent increase in yield, and a 10 per cent reduction in energy consumption.

Our research shows that optimising APCs at processing sites can generate \$15 billion to \$27 billion globally.

How advanced process controls work The way organisations utilise control logic can be visualised as a pyramid. APCs sit near the top, executing set points with base-layer controllers (BLCs) such as programmable logic controllers or distributed control systems (Figure 1).

In this sense, APCs facilitate communication between system-level controls, subsystems (sensors and instruments), and equipment (the actual machinery).

For example, in the mining industry,

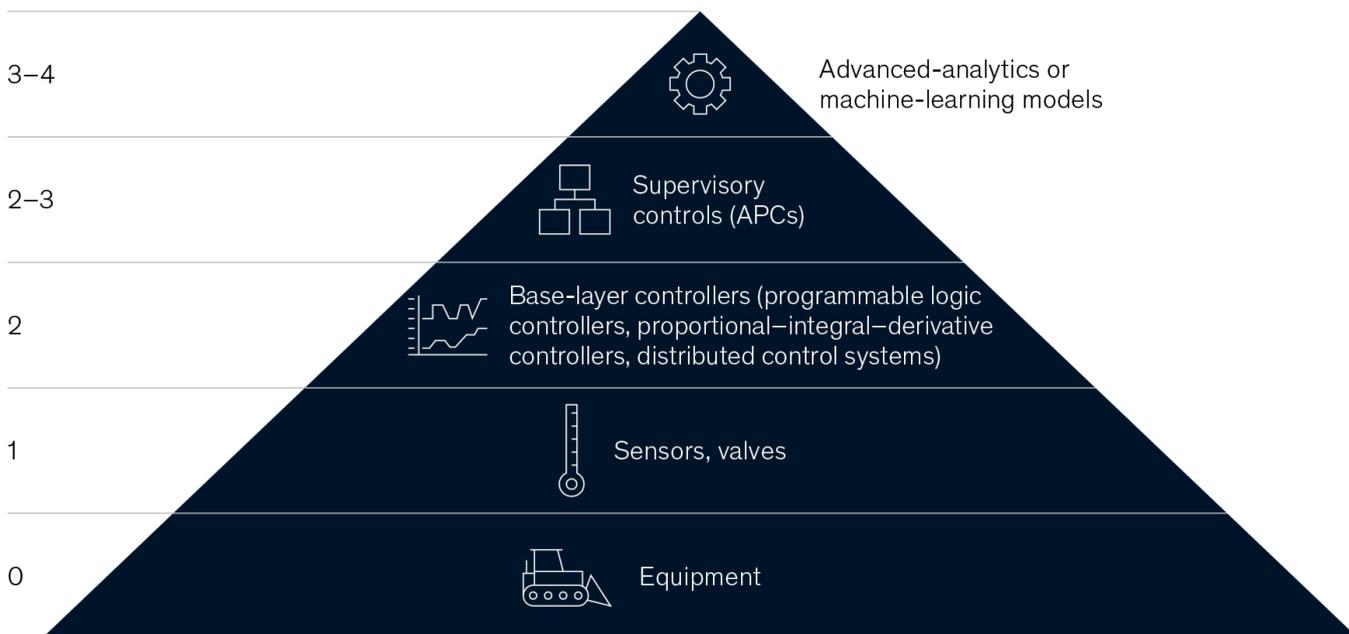
APCs communicate with different feed sources to deliver the target particle mix to a mill to be processed (Figure 2). They also help ensure an optimal retention time by controlling the feed rate of ore and water (otherwise known as "ore hardness"). Each real-time controller drives a single controlled variable to a prescribed set point.

For instance, one controller might adjust the dilution pump's speed to maintain the desired water flow, which informs the APC assigned to retention time.

APCs are only as good as the set-point targets and constraints inputted by operators and the quality of measured process variable data.

## Advanced process controls (APCs) facilitate system-wide communication; compound risk and value at stake increases down the technology stack.

ISA-95<sup>1</sup> reference architecture layer



<sup>1</sup>International Society of Automation standard for manufacturing control systems.

Figure 1

Yet, many companies have neglected reviewing their set-points for years.

Others don't have the required in-house capabilities to maintain their APCs and depend on vendors. Managing these relationships requires clearly defined strategies, and companies that already struggle with optimisation are sometimes left in the dark. Relying solely on an already-lacking, in-house maintenance strategy for underlying control loops, equipment, and sensors will inevitably result in less-than-ideal APC performance.

Those that do have the capabilities to maintain their equipment may still lack the discipline to keep APCs activated and in good health. For example, some operators prefer to run processes manually, given their distrust in APC

performance, further aggravated by a lack of management systems that track or rate performance.

### HOW TO MAXIMISE VALUE FROM ADVANCED PROCESS CONTROLS

CIOs, CTOs, and COOs responsible for optimising their organisations' technologies should closely examine how advanced analytics can be used to generate maximum value from APCs. Doing so requires a comprehensive approach that addresses challenges across three categories: people, processes, and technologies.

- **People.** Improve the utilisation of APCs through better performance management of operators and vendors and take a comprehensive change management approach.
- **Processes.** Improve underlying

layers of APCs with better processes to maintain the health of sensors, instrumentation, and BLCs.

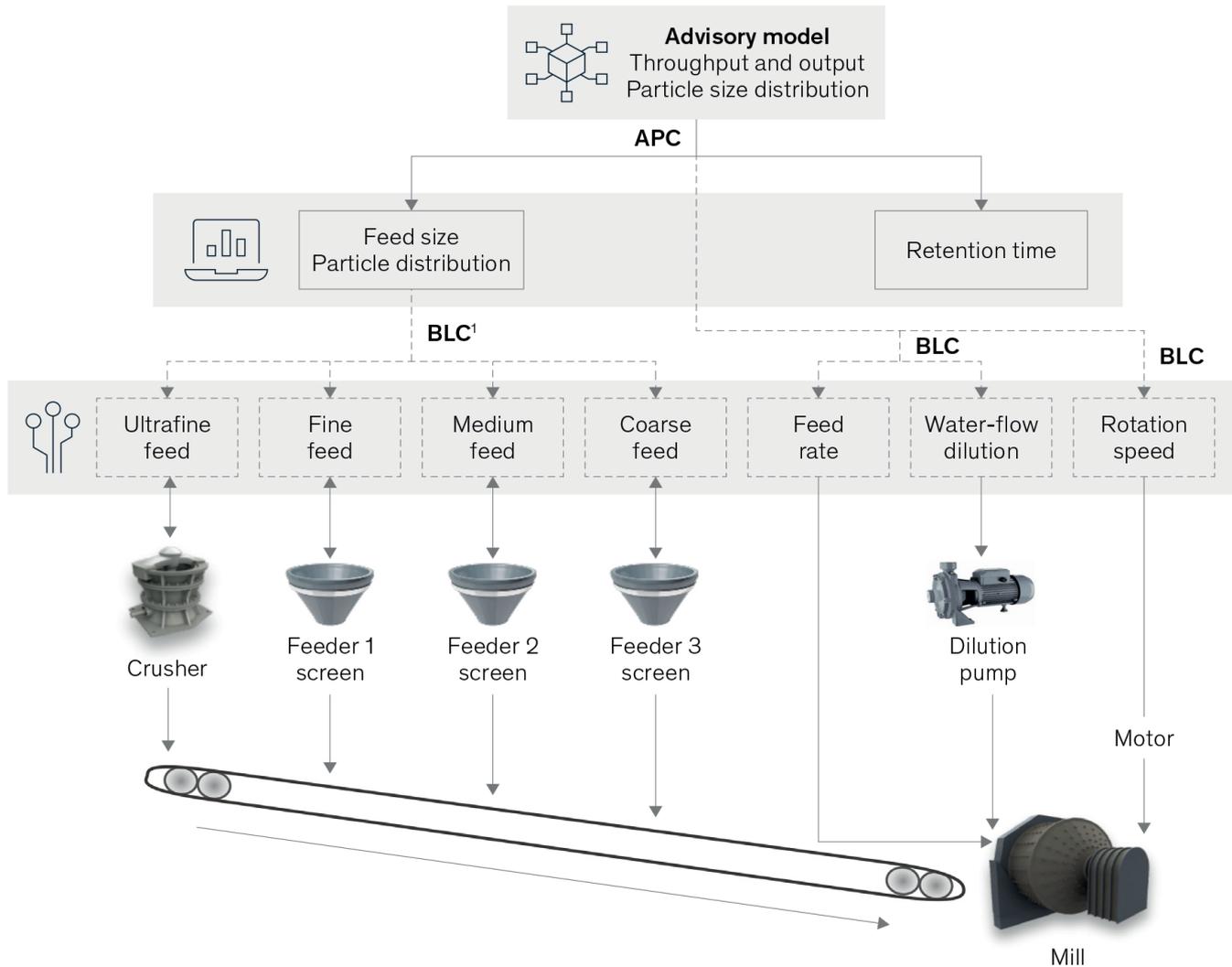
- **Technologies.** Improve APC design and logic by identifying the right objective function and input-output relationships, reviewing the constraints, and employing advanced-analytics models.

The following examples illustrate how APCs can be optimised along with these categories.

#### EXAMPLE 1: BASIC-MATERIALS COMPANY

A North American company that relies on a smelter experienced high variability in slag temperature due to inadequate controls. This irregularity was risky, as dipping below the threshold

## Advanced process controls (APCs) in a mining company can deliver the target particle mix and ensure optimal retention time.



<sup>1</sup>BLC = base-layer controller.

Figure 2

temperature could freeze the slag and halt operations. In response, operators set overly conservative temperature limits, compromising thermal energy that could otherwise be used to improve furnace efficiency—and satisfying a combination of multiple process constraints, including steam flow and the oxygen-to-carbon ratio, further complicated matters. Figure 3.

The company reviewed its process control systems through a comprehensive approach.

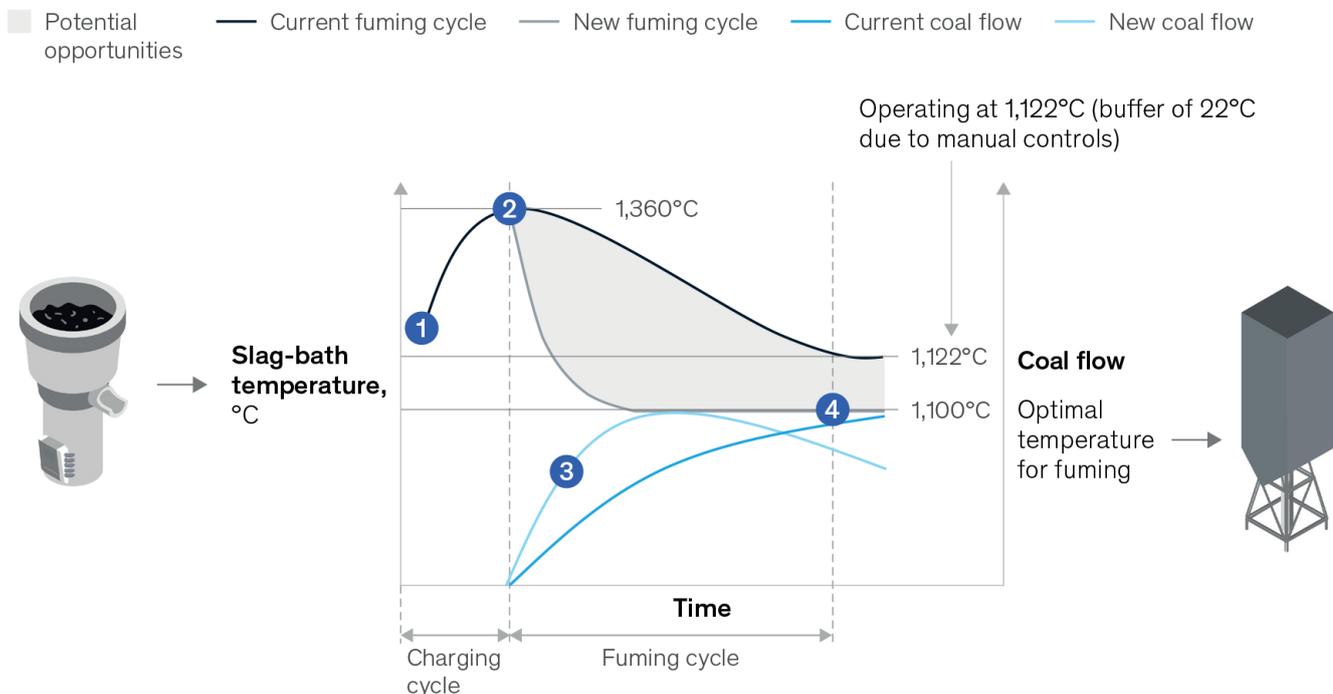
- **People.** Metallurgists and operators were engaged to ensure that each APC was solving the right objective function throughout the optimisation process. And APC-performance dashboards were created for plant leadership to ensure accountability and sustained improvement in APC utilisation.
- **Processes.** A review of the underlying BLCs, sensors, instrumentation, and maintenance records focused on calibrating sensors and coal-flow controllers.

Risk assessment and change-management efforts around control engineers, metallurgists, and operators also complemented this review.

- **Technologies.** Control engineers built predictive models for each output, applying historical data from more than ten million data points collected over two years. A subsequent optimisation algorithm found the best-possible model parameters, thereby improving the logic of the APCs.

## Slag baths need to reach optimal temperature to maximize energy use and increase metal recovery.

### Slag-fuming furnace cycle



- 1 Hot slag is tapped out of furnace.
- 2 The interval of tapping is irregular and depends upon feed rate, furnace capacity, and other factors.
- 3 Coal is added, inducing an endothermic reaction that recovers metal and reduces the slag temperature.
- 4 Maximum metal recovery from fuming cycle is delivered at the optimal temperature of 1,100°C, below which slag freezes.

Figure 3

As a result of this approach, the company increased zinc recovery from the fumer by around 8 per cent.

#### EXAMPLE 2: PULP-AND-PAPER MILL

Despite investing in state-of-the-art equipment and APCs, an extensive North American pulp-and-paper mill suffered heavy operating losses. Its output was well below industry averages, and low fibre quality caused downstream issues in paper and tissue finishing lines.

A review revealed that most operators

had little faith in the mill's critical APCs and instead ran the mill manually. Several APCs had never been correctly set up in the first place, and there was no process to monitor and maintain control loop health. At the instrumentation layer, critical sensors had never been calibrated, effectively rendering particular APCs useless.

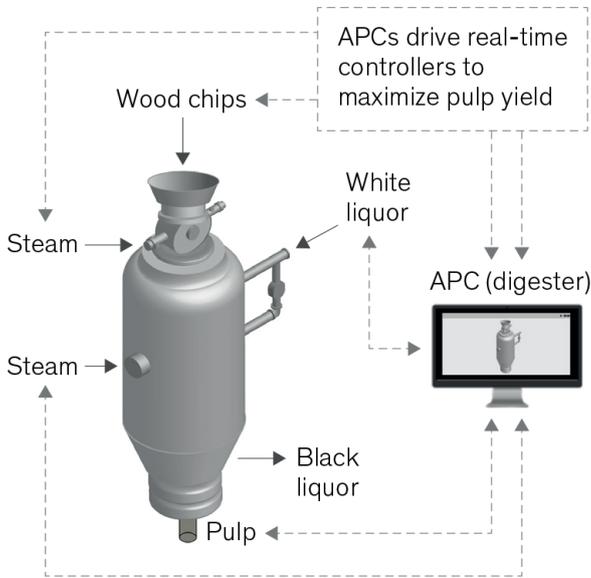
— **People.** Mill leadership set clear expectations with control-room operators regarding APC use and invested in change management to ensure sustainability. These efforts

included implementing visual dashboards and daily shift huddles around APC use and operator education about the functions of the APCs.

— **Processes.** The mill focused on vendor management, employing a program to prepare and calibrate idle APCs to deliver guaranteed performance. This program included identifying instruments that needed to be commissioned or calibrated and holding vendors accountable for testing and monitoring.

# Digesters can optimize advanced process controls (APCs) for pulp-and-paper mills.

## Digester from a pulp-and-paper mill

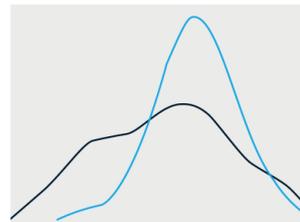


## Results achieved through digester APC optimization

— Before — After

### Hardwood yield distribution

Frequency, number of hours

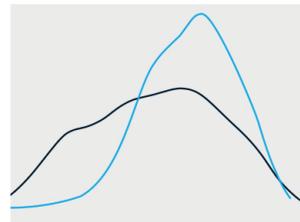


Increased yield from digester by **8% on hardwood** and **5% on softwood**

Yield post screening, %

### Hardwood throughput distribution

Frequency, number of hours



Increased and stabilized throughput, raising **production rates by ~15%**

Kappa¹

¹Kappa indicates pulp's residual lignin content.

Figure 4

— **Technologies.** The company applied advanced-analytics models to provide better set-point recommendations and optimise total mill profit per hour. This ultimately resulted in new targets and centerlines (upper and lower tolerances) for various steps in the process, such as digesting, oxygen delignification, and bleaching.

After 12 weeks, the APC transformation led to \$21 million in earnings before interest, taxes, depreciation, and amortisation, increasing throughput by 15 per cent and yield by 4 per cent (Figure 4).

Companies interested in extracting more value from sub-optimised APCs

should look for any of the following indicators:

- a high degree of variability in critical process indicators, including throughput and recovery
- a low utilisation rate (less than 80 per cent) of existing APCs that control critical processes
- no process to periodically (at least once a year) review APC logic or set points
- no rigorous management system to track the health of underlying BLCs, instrumentation, and sensors

If any of the above conditions are observed, there is likely significant opportunity to unlock additional value through APC optimisation.

Collaborating with APC vendors to identify, calibrate, and tune the crucial underlying BLCs and sensors can be an initial no-regrets move.

Further optimisation initiatives should be prioritised based on impact and feasibility.

With a comprehensive approach based on advanced analytics, companies can now optimise their APCs in a repeatable, time-efficient, and systematic manner, capturing significant improvements in throughput, recovery, and energy savings. **wn**



More recently, the growth of Industry 4.0 and related digital technologies has brought a new methodology onto the scene. Born in the world of software engineering, agile techniques use cross-functional teams, rapid iteration, and regular testing to improve both the speed-to-market and quality of product and service development.

Industrial operations increasingly find themselves at the intersection between these two highly successful improvement approaches.

As an organisation looks to digital solutions to achieve further performance improvements? Should it build and implement those systems



# The right tools for every job: Lean and agile in maintenance

Why tomorrow's maintenance function will combine the strengths of lean and agile organisations.

Over the past seventy years, lean management's focus on reducing waste and process variability through rigorous standardisation and continuous improvement has transformed many industries' operational performance.

**BY** SEBASTIAN HEITZ, MARTIN MAESTU, MATÍAS MARCOTE, AND JOËL THIBERT

within existing lean frameworks, or should it adopt an enterprise-wide agile approach?

Worries about a potential clash are overblown. Although they use different terminology, lean and agile share many fundamentals: both approaches seek to maximise the value delivered to

customers while safely minimising the resources used. Increasingly, agile methods show the potential to address longstanding challenges in many organisations, breaking down silos between different functions or groups of technical specialists, and aiding the efficient allocation of resources in tasks with varying or intermittent workloads.

The challenge for most organisations is not whether they pick one approach over the other, but how they combine the two's strengths to achieve better results.

## AGILE'S POTENTIAL IN MAINTENANCE

One mining organisation's experience illustrates the potential of agile in maintenance, where inefficiencies remain despite the considerable successes companies have had in applying lean approaches.

Much of the difficulty results from the complexity of maintenance organisations, which typically coordinate an extensive range of tasks with varying frequencies, objectives, and work requirements. Moreover, the timing of maintenance interventions may be fixed—or maybe variable based on data extracted from condition-monitoring systems and analytical tools. Amid these uncertainties, planners juggle regular preventative-maintenance activities, emergency repairs, and intermittent upgrades or overhauls. Working closely with colleagues in manufacturing, quality, and procurement, reliability teams design, and execute improvement activities.

The hierarchical structure of maintenance organisations creates a strong tendency for different functional teams, crews, and trades to work mainly in isolation, with planning, execution, and reliability teams usually operating in silos. This tendency is reflected in the organisational-health scores of maintenance organisations, which average seven points lower than those of other operations within the same organisation.

## THE LEAN-AGILE HYBRID

At the mining company, disconnects such as these made delays a chronic problem. The organisation's leaders, therefore, turned to agile principles as a potential solution. But, as they learned, incorporating agile methods into an

existing maintenance organisation isn't trivial. It requires careful coordination between different functions and changes to roles, processes, and working procedures.

The first step in making the lean-agile model work in maintenance was to draw clear distinctions between the different kinds of work involved. As in most maintenance organisations, the mining company's maintenance staff performed three basic types of tasks:

- Optimisation and improvement activities include the design of overall maintenance strategies, the planning of significant shutdowns, and ongoing reliability improvement activities
- Operational support activities include specialised services used to solve problems or implement new processes
- Frontline execution activities include day-to-day preventative-maintenance tasks, troubleshooting, and emergency maintenance work and the execution of planned activities during shutdowns

Each activity type calls for a different team structure. The intensive coordination involved in optimisation and improvement means that an agile cross-functional, the co-located team will likely prove most useful. At the other end of the spectrum, the well-defined tasks characterising frontline execution are a good match for a self-managing team operating under lean principles.

In between, operational-support activities, which involve a degree of regularity but are subject to peaks and valleys of demand, can follow a "flow-to-work" approach combining lean and agile thinking. Personnel

with different expertise join teams as needed, providing the resources necessary to complete projects quickly and effectively (Figure 1).

## AGILE MAINTENANCE OPTIMISATION

For the mining company, the most urgent maintenance problems centred on plant shutdowns—an optimisation-and-improvement issue. Accordingly, it began its agile-maintenance journey by establishing a new cross-functional team dedicated to shutdown planning and execution. The group included personnel from the maintenance function, together with operations and third-party contractor representatives.

Starting with a backlog of possible activities, the agile team worked in a series of agile sprints to define a prioritised list of initiatives completed before and during the shutdown. Each agreed action was given an owner and a deadline. The team tracked its progress using visual workflow-management (or "kanban") boards, a staple lean tool, supplemented with agile digital maintenance-management platform.

This lean-and-agile approach improved both the collaboration between stakeholders and the team's ability to track the shutdown event's overall progress. As a result, the company could dramatically reduce schedule overruns, which had been as high as 25 per cent in previous shutdown events, while reducing the shutdown's overall duration by a meaningful amount.

"Bringing agile to my team has been a major game-changer for shutdown prep," says one of the miner's superintendents. "Now we have a team that is fully devoted to preparing and executing the shutdown, and there

**Maintenance organizations conduct three different types of work that match three team structures.**

Types of work	Methodology	Structure	Examples
 <p><b>Optimization and improvement</b> Creative work: drive continuous improvement by designing and implementing solutions to optimize a process under a minimum-viable-product approach—then refining through iteration.</p>	 <p>Agile</p> <p>Lean</p>	<p><b>Cross-functional teams</b> A cross-functional, co-located team working together day to day and having a defined mission and a clear set of objectives</p>	<p>Data-driven planning optimization and improvement Data-driven plant-reliability impact Observation-based ongoing maintenance-execution improvement</p>
 <p><b>Operational support</b> Perform semiregular activities and can be included ad hoc in continuous-improvement projects calling for specific expertise</p>		<p><b>Flow-to-work teams</b> Center of excellence with specialists that flow dynamically to teams when needed to introduce scarce expertise for a priority piece of work, eg, technical services</p>	<p>Technical-services expert in increasing life of specific equipment HR culture expert to integrate contractors and internal personnel</p>
 <p><b>Frontline execution</b> Repetitive work: run and maintain the organization performing clearly standardized and defined tasks and striving for process excellence in execution.</p>		<p><b>Lean self-managing teams</b> Operational run team that has a defined mission and KPIs for which they are responsible</p>	<p>Plant-shift operations team dedicated to specific facility Shutdowns maintenance-execution team</p>

Figure 1

is no more ambiguity about who’s responsible for what. That allows my organisation to be focused on routine maintenance and follow its standard processes without getting distracted. It’s the best of both worlds.”

Lean and agile methods have much in common, but the two approaches work best when they work side by side for maintenance activities. By understanding each approach’s different strengths and applying them selectively across their organisations, maintenance functions can plan more effectively, resolve issues faster, and execute with greater efficiency. **wn**

# How Optimized Energy Management Delivers Reliability, Efficiency and Sustainability at the Fekola Gold Mine



Since B2Gold first acquired the Fekola gold mine, located in a remote corner of southwest Mali, exploration studies revealed the deposits almost double the initial estimates. A recent site expansion has just been completed. While the existing power units provide enough power to support the increase in production, the company sought to reduce its energy costs, cut greenhouse gas emissions, and increase power reliability.

BY LUKE WITMER, GENERAL MANAGER, DATA SCIENCE, WÄRTSILÄ ENERGY STORAGE AND OPTIMIZATION

A 35MWp solar photovoltaic (PV) plant and 17MW/15MWh of energy storage to the existing 64MW thermal engine plant were decided. This new energy mix is anticipated to save over 13 million litres of fuel, reduce carbon emissions by thirty-nine thousand tons per year, and generate a payback in just over four years.

Such an elaborate hybrid configuration needs a powerful brain to deliver on all its potential: Wärtsilä's GEMS, an advanced energy management system, has been set up to control the energy across the power sources' fleet, thermal, renewable, and battery storage. GEMS's integration, control, and optimisation capabilities allow the



thermal units to be run at the most efficient rate and enable the battery storage to handle the large load step changes and volatility of the solar PV generation assets.

## **INTEGRATED HYBRID ENERGY SOLUTION**

In the Fekola mine context, which is an off-grid electrical island, the battery is performing a lot of different services simultaneously, including frequency response, voltage support, shifting solar energy, and providing spinning reserves. The energy load is very flat, with a steady consumption rate around 40MW as the mining equipment operates 24/7. However, if an engine trips offline and fails, the battery

serves as an emergency backstop. The controls reserve enough battery energy capacity to fill the power gap for the time it takes to get another engine started. The software inside each inverter enables the battery to respond instantaneously to any frequency deviation.

The reciprocating engines operate most efficiently at 85-90 per cent of their capacity; this is their “sweet pot”. But if there is a sudden spike in demand, if a little more power is needed, or if mining equipment is coming online, then another engine needs to be run to meet the extra load. With the battery providing spinning reserves, the engines can

be kept running at their sweet spot, reducing the overall cost per kilowatt-hour. Moreover, with the solar plant providing power during the day, three to four engines can be shut down over this period, providing a quiet time to carry out preventive maintenance. This helps the maintenance cycle, ensuring that the engines operate more efficiently.

Solar PV volatility can be intense. On a bright day with puffy clouds passing by a solar farm of this size can easily see ramps of 25MW over a couple of minutes. This requires intelligent controls, dynamically checking the amount of solar that can be let into the grid without causing an issue for

the engine loadings or overloading the battery.

## CONDUCTING THE ORCHESTRA

The GEMS intelligent software provides the optimisation layer that controls all the power sources to ensure that they work together. The user interface (UI) gives all the data access and presents it in a user-friendly way. Accessible remotely, all operations are simulated on a digital twin in the cloud to verify the system controls and simulate the most efficient operating scenarios to lower energy costs.

This is a crucial software feature, both during and after commissioning. It allows operators to train on the platform ahead of time and familiarise themselves with renewables' automated controls and dynamic curtailment. The UI provides the forecast for renewables and the battery charge status at any given moment; it can push email or phone notifications for alerts; telling operators when to turn off an engine and when to turn it back on.

The software is continuously analysing the data and running the math to solve the economic dispatch requirements and unit commitment constraints to ensure grid reliability and high engine efficiency.

Load forecasting integrates the different trends and patterns that

are detectable in historical data and satellite-based solar forecasting to provide a holistic approach to dispatching power.

The Fekola site has a sky imager, or cloud tracking camera with a fisheye lens that provides solar forecasts for the next half hour in high temporal resolution.

To ensure that operators understand the platform, and have visibility over the advanced controls, the UI provides probability distributions of the solar forecast. Tracking the forecast errors enables operators to see whether the solar is overproducing or underproducing what the prognosis was expecting and provides visibility to the operators on the key performance indicators. This feedback is an integral part of the machine/human interface and provides operators with insight if an engine is required to be turned on at short notice.

Automated curtailment enables the optimisation of the system, providing a reactivity that people cannot match. By continually monitoring the engine loadings and battery, the system is ready to clamp down on solar if it gets too volatile or exceeds some spinning reserve requirement. For example, if a large, unexpected cloud arrives, the battery is dispatched to fill the gap while the engines ramp up. However, once the cloud disappears, the engines

remain committed to operating for a few hours, and solar power is transferred to recharge the battery.

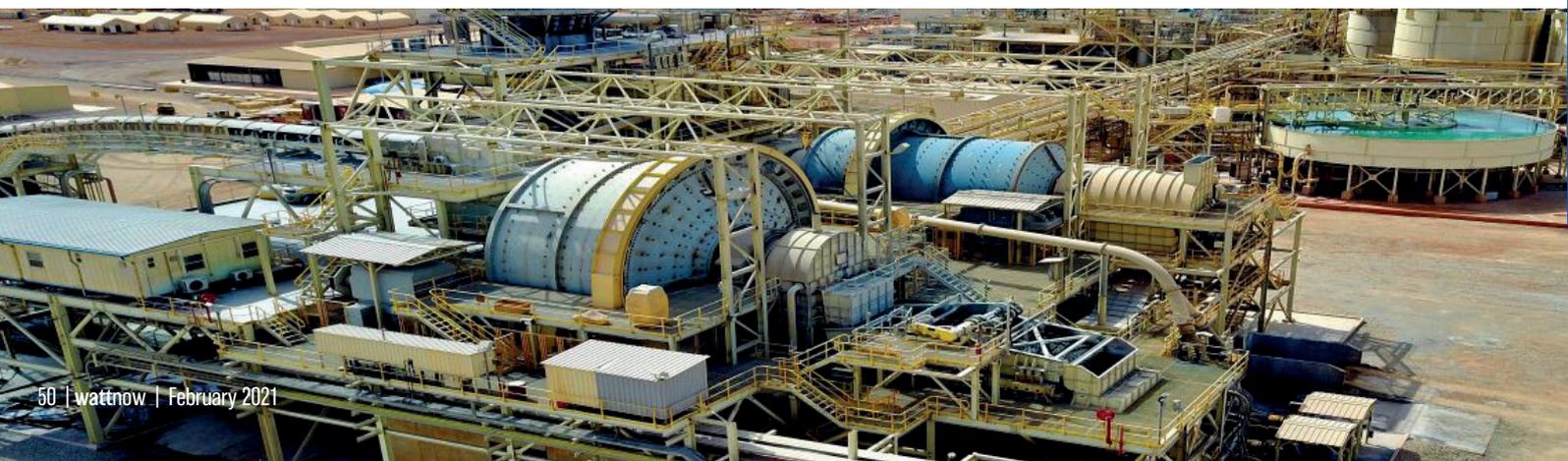
Over time, as load patterns shift, the load forecasting algorithm will also be dynamically updated to match the load's changing realities. As mining equipment hits layers of harder rock, increasing the power load, the system will adjust and dispatch the engines accordingly.

Hybrid solutions will become the new gold standard for off-grid heavy energy users.

The Fekola mine project incorporates the most comprehensive off-grid hybrid power solution globally, demonstrating the growing case for clean energy and its sustainable and economic potential for mines in Africa and beyond.

As the cost of batteries and solar panels continues to become more competitive, hybrid solutions prove to be a practical and effective means for increasing energy reliability and lowering operating costs in any context.

This enables freeing up resources to improve the human condition; whether through cheaper materials and gainful employment, or by providing broader access to reliable electricity for healthcare, education, and improved quality of life. **wn**



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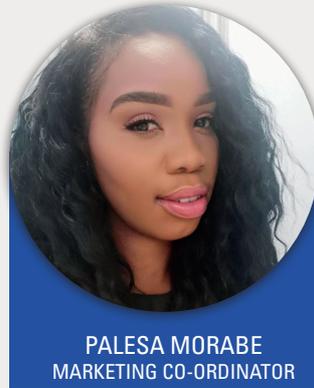
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# Zeptoseconds Breakthrough

Physicists at Goethe University, Frankfurt, in Professor Reinhard Dörner's team, together with colleagues at the accelerator facility DESY in Hamburg and the Fritz-Haber-Institute in Berlin, have for the first time studied a process that lies within the realm of zeptoseconds.

**BY** DUDLEY BASSON

They measured how long it takes for a photon to cross a hydrogen molecule: about 247 zeptoseconds for the average bond length of the molecule. This is the shortest timespan that has been successfully measured to date. Before proceeding, let us attempt to visualise the magnitude of the SI prefix zepto (symbol  $z = 10^{-21}$ ). Visualising ultra-short time intervals is practically impossible so let us apply the zepto prefix to length dimensions.

Starting with an astronomical unit,

which is based on the Earth-Sun distance (one AU =  $1,496 \times 10^{11}$  metres) a zeptoAU would give us 0,1496 nanometres which is too small to visualise. Let us try using a light-year  $9,460\ 55 \times 10^{15}$  metres which is about a quarter of the way to the nearest stars in the Milky Way galaxy. A zeptoLY would give us 9,46 microns which is less than the thickness of lightweight cling-wrap

In the prefix table given it will be seen that a nanosecond is a millionth

of a millisecond, a femtosecond is a millionth of a nanosecond and a zeptosecond is a millionth of a femtosecond.

To briefly digress, the following [video clip](#) illustrates the extremely small measurements encountered in gravitational wave observatories.

It must be noted that below the picometre range, the concept of a smooth polished surface is meaningless.





### SMALL SI PREFIXES

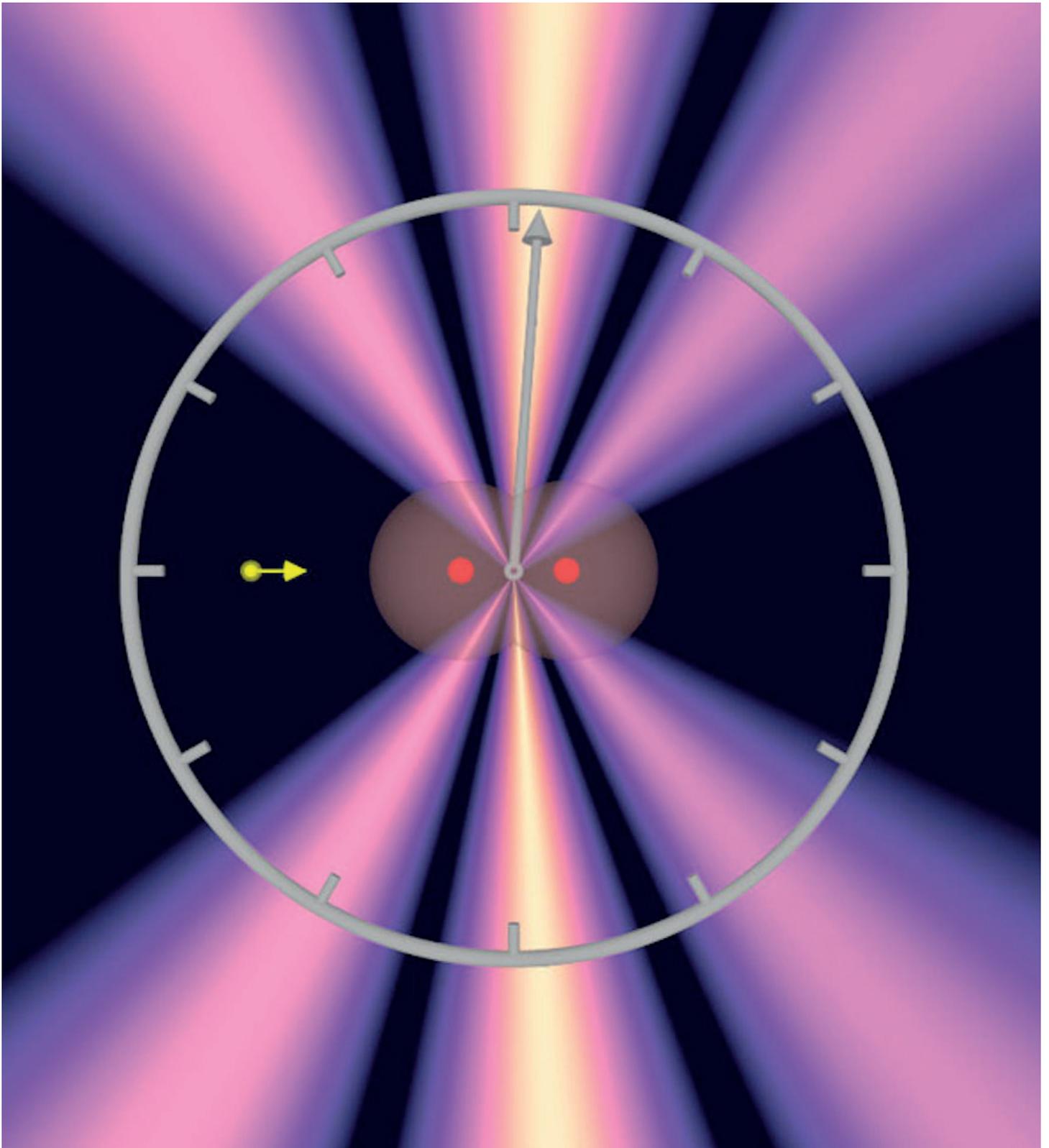
m milli	$10^{-3}$
$\mu$ micro	$10^{-6}$
n nano	$10^{-9}$
p pico	$10^{-12}$
f femto	$10^{-15}$
a atto	$10^{-18}$
z zepto	$10^{-21}$
y yocto	$10^{-24}$

This [video](#) illustrates the extremely large and extremely small dimensions of the universe as well as an explanation of the ultimate small dimension of the universe, the Planck Length.

In 1999, the Egyptian chemist Ahmed Zewail received the Nobel Prize for measuring the speed at which molecules change their shape. He founded femtochemistry using ultrashort laser flashes: the formation and breakup of chemical bonds occurs in the realm of femtoseconds.

The atomic physicists at Goethe University carried out the time measurement on a hydrogen molecule ( $H_2$ ) which they irradiated with X-rays from the X-ray laser source PETRA III at the Hamburg accelerator facility DESY. The researchers set the energy of the X-rays so that one photon was sufficient to eject both electrons out of the hydrogen molecule.

Electrons behave like particles and waves simultaneously, and therefore the ejection of the first electron



*COLTRIMS The Cold Target Recoil Ion Momentum Spectrometer*

*© Credit: Sven Grundmann, Goethe University, Frankfurt.*

resulted in electron waves launched first in the one, and then in the second hydrogen molecule atom in quick succession, with the waves merging.

The photon behaved here much like a flat pebble that is skimmed twice across the water: when a wave trough meets a wave crest, the waves of the first and second water contact cancel each other, resulting in an interference pattern.

The scientists measured the interference pattern of the first ejected electron using the COLTRIMS reaction microscope, an apparatus that Dörner helped develop and which makes ultrafast reaction processes in atoms and molecules visible.

Simultaneously with the interference pattern, the COLTRIMS reaction microscope also allowed the determination of the orientation of the hydrogen molecule. The researchers here took advantage of the fact that the second electron also left the hydrogen molecule, so that the remaining hydrogen nuclei flew apart and were detected.

*“Since we knew the spatial orientation of the hydrogen molecule, we used the interference of the two electron waves to precisely calculate when the photon reached the first and when it reached the second hydrogen atom,”* explains Sven Grundmann whose doctoral dissertation forms the basis of the scientific article in Science. *“And this is up to 247 zeptoseconds, depending on how far apart in the molecule the two atoms were from the perspective of light.”*

Professor Reinhard Dörner adds: *“We observed for the first time that the electron shell in a molecule does not react to light everywhere at the same time. The time delay occurs because information within the molecule only spreads at*

*the speed of light. With this finding we have extended our COLTRIMS technology to another application.”* [Citation](#)

## **COLTRIMS THE COLD TARGET RECOIL ION MOMENTUM SPECTROMETER**

The photon (yellow, coming from the left) produces electron waves out of the electron cloud (grey) of the hydrogen molecule (red: nucleus), which interfere with each other (interference pattern: violet-white). The interference pattern is slightly skewed to the right, allowing the calculation of how long the photon required to get from one atom to the next.

## **ULTRAFAST CAMERA**

The California Institute of Technology announced an ultrafast camera that can capture 3-D videos at 100 billion frames per second.

The more senior amongst us will remember taking 8mm home movies at 16 frames per second giving each frame a 1/35th second exposure. At that time 8mm colour film had a speed of 10 ASA which required films to be taken in sunlight or equivalent floodlighting.

The Rosalind Franklin Institute (Harwell, Oxfordshire, England) is funded to develop the world's best ultrafast video camera for imaging tissue with greater sensitivity and at higher resolution than any other instrument currently available.

They say the camera will be invaluable in developing new techniques that use sound and light for both detecting and treating disease, including some of the most lethal forms of cancer such as pancreatic and brain tumours, with minimal side effects for patients.

Compressed ultrafast photography (CUP) was a good starting point then. At 100 billion frames per second, this method approached, but did not meet, the specifications required to integrate femtosecond lasers. To improve on the concept, the new T-CUP system was developed based on a femtosecond streak camera that also incorporates a data acquisition type used in applications such as tomography.

*“We knew that by using only a femtosecond streak camera, the image quality would be limited,”* says professor Lihong Wang, the Bren Professor of Medical Engineering and Electrical Engineering at Caltech and the Director of Caltech Optical Imaging Laboratory (COIL).

*“So to improve this, we added another camera that acquires a static image. Combined with the image acquired by the femtosecond streak camera, we can use what is called a Radon transformation to obtain high-quality images while recording ten trillion frames per second.”*

Setting the world record for real-time imaging speed, T-CUP can power a new generation of microscopes for biomedical, materials science, and other applications. This camera represents a fundamental shift, making it possible to analyse interactions between light and matter at an unparalleled temporal resolution.

The first time it was used, the ultrafast camera broke new ground by capturing the temporal focusing of a single femtosecond laser pulse in real time. This process was recorded in 25 frames taken at an interval of 400 femtoseconds and detailed the light pulse's shape, intensity and angle of inclination.

In his quest to bring ever-faster cameras to the world, Caltech's Lihong

Wang has developed technology that can reach blistering speeds of 70 trillion frames per second, fast enough to see light travel.

Now, Wang's lab has gone a step further to create a camera that not only records video at incredibly fast speeds but does so in three dimensions. Wang, Bren Professor of Medical Engineering and Electrical Engineering in the Andrew and Peggy Cherng Department of Medical Engineering, describes the device in a new paper in the journal *Nature Communications*.

The new camera, which uses the same underlying technology as Wang's other compressed ultrafast photography (CUP) cameras, is capable of taking up to 100 billion frames per second. That is fast enough to take 10 billion pictures, more images than the entire human population of the world, in the time it takes you to blink your eye.

Wang calls the new iteration "*single-shot stereo-polarimetric compressed ultrafast photography*," or SP-CUP.

In CUP technology, all of the frames of a video are captured in one action without repeating the event. This makes a CUP camera extremely quick (a good cell-phone camera can take 60 frames per second). Wang added a third dimension to this ultrafast imagery by making the camera "see" more like humans do.

When a person looks at the world around them, they perceive that some objects are closer to them, and some objects are farther away. Such depth perception is possible because of our two eyes, each of which observes objects and their surroundings from a slightly different angle. The information

from these two images is combined by the brain into a single 3-D image.

The SP-CUP camera works in essentially the same way, Wang says: "*The camera is stereo now*," he says. "*We have one lens, but it functions as two halves that provide two views with an offset. Two channels mimic our eyes.*"

Just as our brain does with the signals it receives from our eyes, the computer that runs the SP-CUP camera processes data from these two channels into one three-dimensional movie.

SP-CUP also features another innovation that no human possesses: the ability to see the polarization of light waves.

The polarization of light refers to the direction in which light waves vibrate as they travel. Consider a guitar string. If the string is pulled upwards (say, by a finger) and then released, the string will vibrate vertically. If the finger plucks it sideways, the string will vibrate horizontally. Ordinary light has waves that vibrate in all directions.

Polarized light, however, has been altered so that its waves all vibrate in the same direction. This can occur through natural means, such as when light reflects off a surface, or as a result of artificial manipulation, as happens with polarizing filters.

Though our eyes cannot detect the polarization of light directly, the phenomenon has been exploited in a range of applications: from LCD screens to polarized sunglasses and camera lenses in optics to devices that detect hidden stress in materials and the three-dimensional configurations of molecules.

Wang says that the SP-CUP's combination of high-speed three-dimensional imagery and the use of polarization information makes it a powerful tool that may be applicable to a wide variety of scientific problems. In particular, he hopes that it will help researchers better understand the physics of sonoluminescence, a phenomenon in which sound waves create tiny bubbles in water or other liquids. As the bubbles rapidly collapse after their formation, they emit a burst of light.

*"Some people consider this one of the greatest mysteries in physics,"* he says. *"When a bubble collapses, its interior reaches such a high temperature that it generates light. The process that makes this happen is very mysterious because it all happens so fast, and we're wondering if our camera can help us figure it out."*

The paper describing the work, titled, "*Single-shot stereo-polarimetric compressed ultrafast photography for light-speed observation of high-dimensional optical transients with picosecond resolution*," appears in the October 16 2020 issue of *Nature Communications*. Co-authors are Jinyang Liang, formerly of Caltech now at the Institut National de la Recherche Scientifique in Quebec; Peng Wang, postdoctoral scholar in medical engineering; and Liren Zhu, a former graduate student of the Wang lab.

Funding for the research was provided by the National Institutes of Health.

[Citation:](#)

In August 2016 the Department of Energy's SLAC National Accelerator Laboratory announced that an ultrafast 'electron camera' had made the first direct snapshots of atomic nuclei in

molecules that were vibrating within femtoseconds after being hit by a laser pulse. The method, called ultrafast electron diffraction (UED), could help scientists better understand the role of nuclear motions in light-driven processes that naturally occur on extremely fast timescales.

Researchers used the UED instrument's electron beam to look at iodine molecules at different points in time after the laser pulse. By stitching the images together, they obtained a "molecular movie" that shows the molecule vibrating and the bond between the two iodine nuclei stretching almost 50 percent – from 0,27 to 0,39 nanometres before returning to its initial state. One vibrational cycle took about 400 femtoseconds.

*"We've pushed the speed limit of the technique so that we can now see nuclear motions in gases in real time."* Said co-principal investigator Xijie Wang, SLAC's lead scientist for UED. *"This breakthrough creates new opportunities for precise studies of dynamic processes in biology, chemistry and materials science."*

The UED method has been under development by a number of groups throughout the world since the 1980s. However, the quality of electron beams has only recently become good enough to enable femtosecond studies.

SLAC's instrument benefits from a high-energy, ultra-bright electron source originally developed for the lab's femtosecond X-ray laser, the Linac Coherent Light Source (LCLS), a DOE Office of Science User Facility.

Physicists have long known that chemical bonds between atoms are

flexible – like springs connecting spheres. This flexibility allows molecules to change shape in ways that are crucial for biological and chemical functions, such as vision and photosynthesis. However, methods to study these motions on a femtosecond timescale have so far been indirect.

Spectroscopy, for example, infers these changes from the way laser light interacts with electron clouds around atomic nuclei, and requires theoretical calculations to turn these data into a picture of the nuclear geometry.

This can be done very precisely for small molecules – an accomplishment achieved by the late Ahmed Zewail, a pioneer in the field of femtochemistry – but quickly becomes very challenging for larger molecules.

Researchers also use X-rays to study ultrafast molecular motion. Although X-rays deeply penetrate the electron clouds, interacting with the electrons closest to the nuclei, they don't yet do so with high enough resolution to precisely determine the nuclear positions in current femtosecond X-ray studies.

In contrast, UED uses a beam of very energetic electrons that interacts with both electrons and atomic nuclei in molecules. Therefore, it can directly probe the nuclear geometry with high resolution.

*"We previously used the method to look at the rotation of molecules – a motion that doesn't change the nuclear structure,"* said lead author Jie Yang from SLAC, who was at the University of Nebraska, Lincoln at the time of the study. *"Now we have demonstrated that we can also see bond changes due to vibrations."*

The concept behind the iodine UED experiment is similar to the classical double-slit experiment often demonstrated in physics classrooms. In that experiment, a laser beam passes through a pair of vertical slits, producing an interference pattern of bright and dark stripes on a screen. The pattern depends on the distance between the two slits.

In the case of UED, an electron beam shines through a gas of iodine molecules, with the distance between the two iodine nuclei in each molecule defining the double slit, and hits a detector instead of a screen. The resulting intensity pattern on the detector is a diffraction pattern.

*"The characteristic pattern tells us immediately the distance between the nuclei,"* said co-principal investigator Markus Guehr from Potsdam University in Germany and the Stanford PULSE Institute.

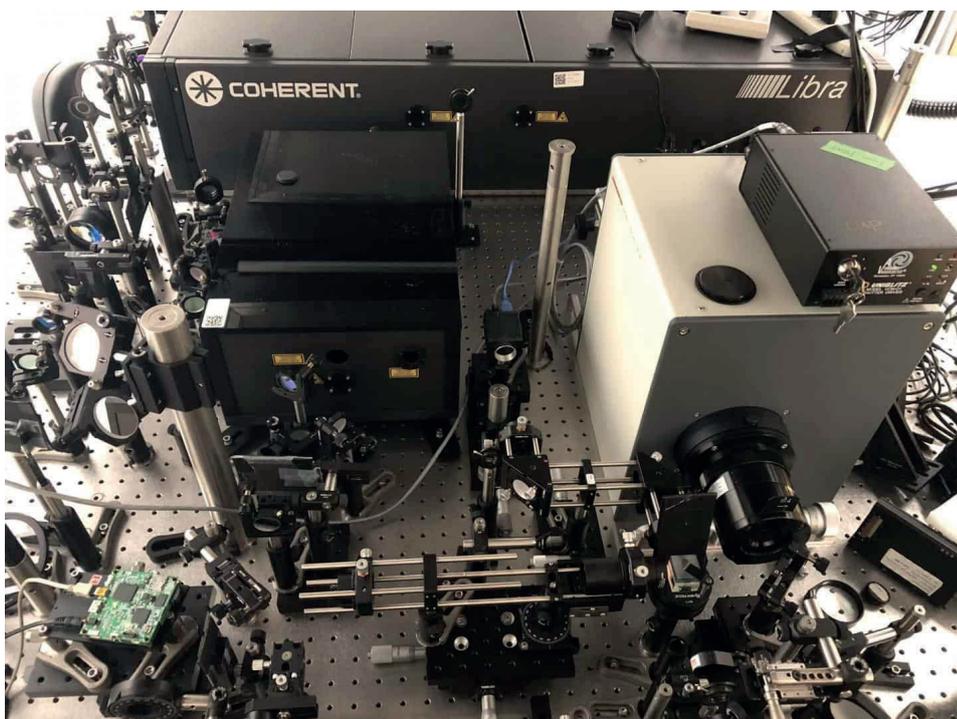
*"But we can learn even more. As the iodine molecules vibrate, the diffraction pattern changes, and we can follow the changes in nuclear separation in real time."*

Co-principal investigator Martin Centurion from the University of Nebraska, Lincoln, said, *"What's also great about our method is that it works for every molecule. Unlike other techniques that depend on the ability to calculate the nuclear structure from the original data, which works best for small molecules, we only need to know the properties of our electron beam and experiment setup."*

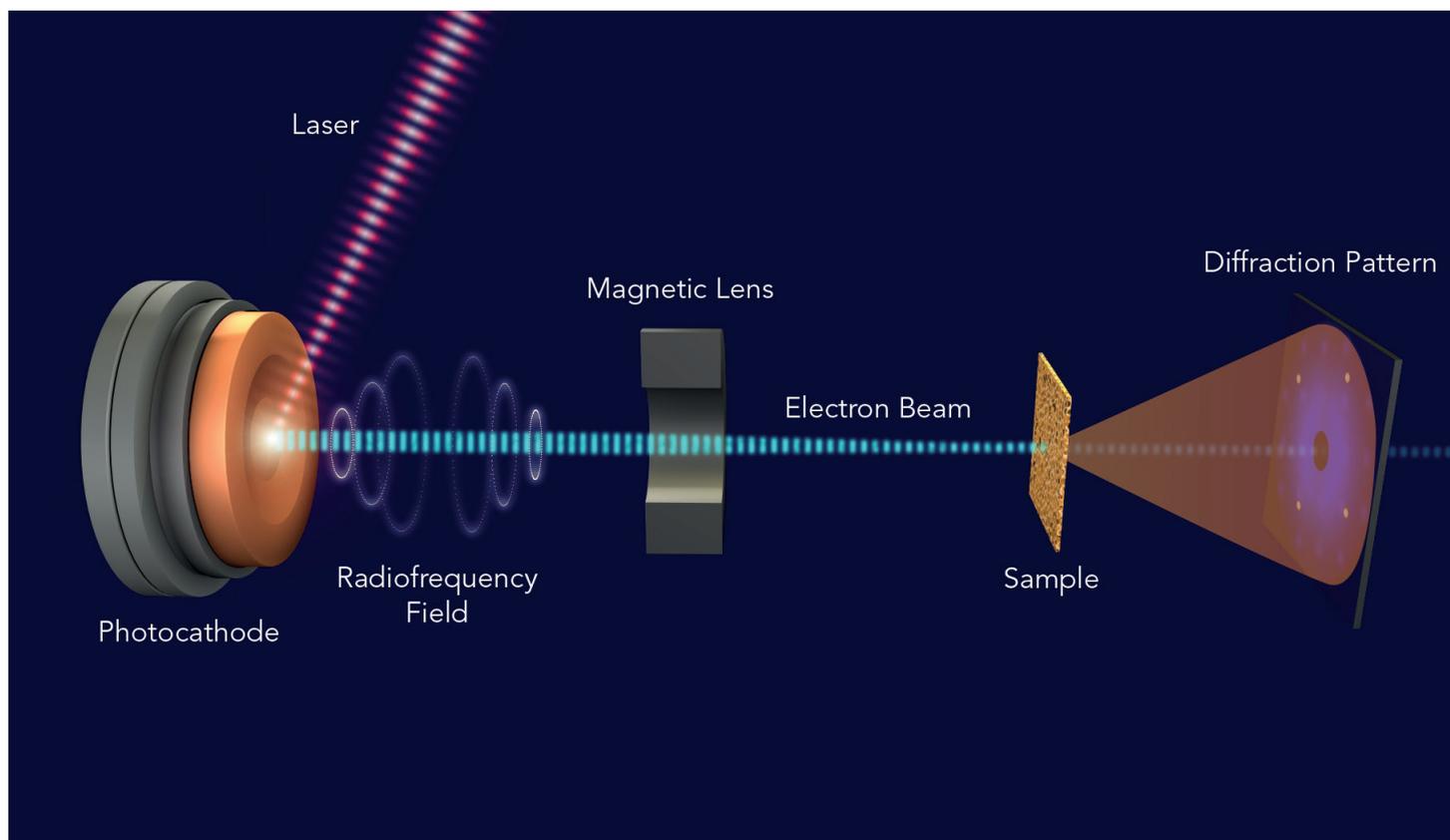
Following their first steps using the relatively simple iodine molecule, the team is now planning to expand their studies to molecules with more than two atoms.

*"The development of UED into a technique that can probe changes in internuclear distances of a dilute gas sample in real time truly is a great achievement."* Said Jinming Cao, a UED expert from Florida State University and a former member of Zewail lab at the California Institute of Technology, who was not involved in the study. *"This opens the door to studies of atomic level motions in many systems – structural dynamics that are at the heart of the correlation between structure and function in matter."*

[Citation](#) **wn**



*Shown here is the trillion-frame-per-second compressed ultrafast photography system (T-CUP)  
Image credit: INRS – Institut National de la Recherche Scientifique, Quebec.*



*UED – Ultrafast electron diffraction reveals rapid motions of atoms and molecules*



# Copper is found in all Energy Systems

Whether powered by sun, wind or water, efficient and renewable energy systems rely on copper to transmit the energy they generate with maximum efficiency and minimum environmental impact.

## Superior conductivity of copper and recyclability

Copper is a preferred electrical conductor and an excellent thermal conductor. Superior conductivity allows smaller conductors to be used, saving space and cost.

Copper is infinitely recyclable without any loss of performance and is nearly indistinguishable from freshly mined copper. It is estimated that 80 percent of all copper ever mined during the past 10,000 years is still in use somewhere today. Estimates also reveal that 33 percent of today's world annual copper demand is supplied by recycled copper.

## Copper's contributions towards reducing greenhouse gas emissions

Increasing the cross section of wires and cables, overhead railway lines, and motor and transformer windings can significantly increase electrical energy efficiency. Incorporating one extra kilogram of copper can save between 100 and 7,500 kilograms of greenhouse gas emissions (CO<sub>2</sub>). Every conductor in an electrical system has a built-in resistivity. This means that part of the electrical energy it carries is dissipated as heat and lost as useful energy. Generating this wasted electrical energy produces carbon emissions and consequently contributes to global warming. An important initial decision, in seeking to reduce these losses, is to use copper as the conductor.

## Renewable energy

Copper plays an important role in renewable energy systems. By using copper instead of other lower electrical energy-efficient metal conductors, less electricity needs to be generated to satisfy a given power demand.

Copper has long been used in solar heating/hot water systems, where it is commonly used in heat exchangers. Now, it promises to become equally valuable in photovoltaic (PV) and wind systems.

Longer-term programmes, such as wind powered production processes and the electrification of thermal processes, are less certain and will require economic incentives and significantly more development to build technical viability. However, in light of the very large savings potentials, close to 300 million tonnes of CO<sub>2</sub> per year, they are worthy of further investment and investigation. It should be clear then that CDAA shares the European Copper Institute's vision for a low-carbon economy and will pursue it with all of the resources at its disposal. We urge policymakers to support a reasoned balance between the energy needed to manufacture the building blocks of that new economy and the overarching goals for reduced energy demand and carbon emissions.

## The CDAA and ECI role in reducing energy consumption

The CDAA and European Copper Institute have developed strategies that will both trigger and support substantial carbon reductions in the downstream industrial, residential and service sectors.

Electric motors account for a large amount of the electricity consumed by industry. Energy-efficient motor driven systems could save electricity consumption, resulting in reduced maintenance, improved operations and reduced environmental costs.

Cable size is very important for the correct operation of any electrical circuit. Selecting too small conductors for an application could compromise the operation of the circuit: it causes voltage drop, poor performance and in extreme cases the cable temperature will increase enough to melt the insulation. On the contrary, selecting too large conductors increases costs and weight. Please view Leonardo ENERGY's website for courses offered:

<http://www.leonardo-academy.org/course/index.php?categoryid=72>

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## FEBRUARY 2021

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