



ACCELERATING INNOVATION: SHAPING THE FUTURE OF MINING TOGETHER

The Mining Indaba serves as an opportunity for the CSIR to showcase tailor-made capabilities designed for the modernisation of mining, emphasise the commitment to safety and security in the mining sector, introduce innovation partners to the mining industry at large, and showcase relevant innovations jointly.

The Department of Science and Innovation (DSI) in partnership with the Council for Scientific and Industrial Research (CSIR) and the Mandela Mining Precinct (MMP) are set to engage in Africa's largest investment mining event, the African Mining Indaba Investment Conference, taking place from 4 – 8 February 2024.



science & innovation

Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA



CSIR
Touching lives through innovation



MANDELA MINING PRECINCT
MINDS FOR MINES



FOREWORD BY MINISTER OF HIGHER EDUCATION, SCIENCE AND INNOVATION, DR BLADE NZIMANDE

South Africa continues to be one of the world's leading mining and mineral-processing countries, with a long-standing and highly developed mining sector. Maintaining our global leadership position relies heavily on how quickly the country can modernise and develop sustainable technologies to make it more competitive.

As such, the Department of Science and Innovation (DSI) is leading science, technology and innovation activities that focus on revitalising mining research and innovation in South Africa to ensure the sustainability of the local mining industry. The aims are to improve the safety of mines, introduce innovative technologies, as well as to understand how modernisation will impact people in the minerals sector.

The department appreciates the invitation from the Department of Mineral Resources and Energy to participate in this single largest mining

event in Africa, which brings together visionaries and innovators across the entire mining value chain under one roof.

This year the department is working in partnership with the Council for Scientific and Industrial Research (CSIR) and the Mandela Mining Precinct (MMP) to showcase locally developed capabilities and research outcomes designed for the modernisation of mining, emphasise the commitment to safety and security in the mining sector, and position the collective as innovation partners and research facilitators for the mining industry. This significant partnership takes place under the auspices of the MMP to drive mining research in South Africa.

In line with the conference theme, the DSI collective will focus on the sub-theme "Accelerating Innovation: Shaping the Future of Mining Together", presenting locally developed innovations in the mining industry.

It is a proven fact that research and development (R&D) within mining is the key to unlocking its growth potential and thereby increasing local economic growth, ensuring new employment opportunities, and achieving a more inclusive and equal society. This can only be done through partnerships, and the department is happy that its collaborations with industry and the trade unions continue to strengthen and accrue benefits.

The MMP is jointly hosted by the Minerals Council of South Africa and the CSIR, and was established to revitalise mining research, development and innovation (RDI) in South Africa.

Through this partnership, we developed the South African Mining Extraction Research Development and Innovation (SAMERDI) strategy, which is aimed at materially improving the technological base of mining in South Africa.

The DSI has made significant financial and other investments in SAMERDI, which include, among others, the development of project charters and journey maps for research areas as well as RDI networks and partnerships with universities. It also facilitated the Isidingo Drill Challenge, from which two new rock drill prototypes were developed for easier operation with improved environmental and operator benefits. One of the rock drills has already seen uptake within a commercial environment.

It must also be noted that according to the latest National Survey of Research and Experimental Development 2020/21, mining and quarrying increased its R&D by R241 million to reach a total of R927 million. We would like to see this upward trend continue.

While we are keen to embrace modernisation and innovation, develop new technologies, and mechanise and automate, all our efforts must be people-centred. This makes collaboration with employers, government, unions and NGOs even more important.

This occasion is therefore equally important to us as the Ministry of Higher Education, Science and Innovation because it supports education, career development, sustainable development and other important causes in Africa.

As the Minister of Higher Education, Science and Innovation I look forward to seeing the increased networking and deliberations at this year's Mining in Africa Indaba that will benefit all on the continent.

**DR BE NZIMANDE, MP
MINISTER OF HIGHER EDUCATION, SCIENCE AND
INNOVATION**

FROM CSIR CHIEF EXECUTIVE OFFICER DR THULANI DLAMINI

The mining sector has undergone notable changes over the years, which have caused the industry to transform its operations. More than ever before, there is a call to re-imagine the future of mining. With operational costs increasing, productivity challenges, questions about safety and security, as well as the widespread illegal mining problem in South Africa, the mining sector is continually seeking innovative ways to sustain itself.

Mining is one of the top three contributors to the South African economy in terms of GDP and employment in South Africa. As the Council for Scientific and Industrial Research (CSIR), we aim to support industries such as mining, to drive Research development and innovation to carve out competitive advantages for South Africa. Thus, over the years, the CSIR has contributed significantly to the industrial and economic growth of the mining industry through the development of specialised solutions. These solutions included the adaptation of bespoke radar technology solutions for mining aimed at assisting mines to optimise minerals extraction while also contributing to the zero-harm objective. Through the annual monitoring and legislated performance acceptance testing of facilities enabling safer mining operations and rock engineering capabilities to support safe, deep-level mining operations.

Following the transfer of technical capabilities from COMRO, to the CSIR, the organisation became a steward for driving research development and innovation in the South African mining industry as well as building an innovation ecosystem giving rise to the establishment of mining technical services and associations, such as Coaltech.

The CSIR for Mining strategy identifies five Mining industry business value drivers aimed at supporting mining sustainability. These include 1) driving zero harm, 2) Improvements to the environment and building a circular economy, 3) driving down cost of production through improving efficiency and productivities, 4) Improving resource utilisation and 5) Building capabilities to support people centred mine modernisation.

We are delighted to have a multidisciplinary team of CSIR experts attend the Mining Indaba in 2024, as we collaborate with the mining industry to Innovative and shape the *Future of Mining Together*. The CSIR aims to showcase bespoke innovations that are aligned with the investment conference theme "Embracing the Power of Positive Disruption: A Bold New Future for African Mining." We



will demonstrate our collaboration with different mining industry stakeholders on developing bespoke innovations to support mining business value drivers, as outlined below:

- i. Supporting Zero harm Competency-based safety training using immersive technologies.
- ii. Safety and security solutions for the mining industry showcasing application of Synthetic Aperture Radar and CMORE solutions.
- iii. Supporting safe, productive, and efficient innovations CSIR Information and Cyber Security capabilities, Collision prevention digital twin and cutting-edge data analytics services capabilities, RTIMS underground networks and communication research, in partnership with the Mandela Mining Precinct, application of additive manufacturing and Laser-Based refurbishment for on demand part manufacturing.
- iv. Supporting safe and optimum resource utilisation the application of Integrated Geosensing tools and risk-based mapping platform technology to support informed decision making in mining.
- v. Supporting mining environmental sustainability Water centre showcasing treatment of acid mine water drainage to portable water, Hydrogen dual fuel engine technology to support decarbonisation efforts, application of Energy centre capabilities to optimise energy and building a circular economy roadmap for the mining industry.



FROM MMP DIRECTOR, JULIE COURTNAGE

The Mandela Mining Precinct (MMP), launched in 2018, carries the name of the former President of South Africa (SA), Nelson Mandela, in tribute to his legacy of bringing people together to work on challenges and find solutions. In this case, challenges facing the mining industry in South Africa and the region: thus, Minds for Mines.

During the past five years, the MMP has made excellent progress in implementing a range of programmes in support of the SAMERDI strategy, details of which are on our website. The SAMERDI strategy and business plans are executed through a group of research collaborators/partners associated mainly with universities and other

research entities. The projects are undertaken collaboratively by a team of researchers from the identified research partners, facilitated and managed by the MMP team. Operating transparently, the MMP publishes **Expressions of Interest (Eoi)** at times to expand the group of **collaborative partners** associated with the MMP's programmes. Through these Eoi's, the MMP has managed to expand its **R&D partners and collaborator pool**, which has facilitated delivery against its strategic objectives. This is strongly aligned with our MMP focus on growing the knowledge base and skills, capacity and capability in the mineral extraction space. The MMP also facilitates capacity development through the establishment and oversight of five SAMERDI Research Centres with the Universities of Johannesburg, the Witwatersrand, Pretoria and the Free State, through bursaries from the DSI for Masters, PhD and post-doctoral studies.

Unions are vital stakeholders in the mining sector. In 2021, the MMP signed a **ground-breaking agreement with five unions**, representing the majority of 450,000 mineworkers, to ensure all direct stakeholders can participate at a strategic and policy level in its research and development planning for a modernised mining industry. The Precinct's Organised Labour Consultative (OLC) Forum was thus formally established on 26 October 2021 with the signing of a Terms of Reference at the CSIR International Convention Centre in Pretoria giving effect to its formation.

As part of building stronger stakeholder networks, the MMP and Huawei **signed a memorandum of understanding (MoU)** that allows the Minerals Council, through the MMP and Huawei, to explore the possibilities of achieving underground communications in conventional mines. In addition, an MoU has also been concluded with Mining Equipment Manufacturers of South Africa (MEMSA) and we are currently finalising MoUs with the Mine Health and Safety Council as well as MINTEK, to advance a variety of research needs.

In addition, the MMP has initiated the establishment of an **underground test facility** to test, develop and demonstrate new technologies for the modernisation of mining. A rigorous feasibility study and legal framework were completed with positive outcomes and this resulted in an **MoU** between Impala Bafokeng Limited, CSIR and the Minerals Council. The focus going forward is to equip and operationalise the test mine for the full scope of MMP-related research, with some low-risk testing already taking place.

Increasingly, the MMP is also being called on to support broader issues affecting the mining sector, and a number of strategic initiatives are being pursued in collaboration with a range of research partners.



OVERVIEW

Operation Phakisa in the minerals sector was convened in 2015, with the aim of identifying key constraints to investment and growth, as well as developing a shared vision and growth strategy for the long-term development and transformation of the sector. A number of initiatives emanated from this process, including advancing the cluster through mining research and development, the establishment of a coordination hub and the implementation of research and development (R&D) programmes.

The South African Mining Extraction Research, Development and Innovation (SAMERDI) Strategy and the Mandela Mining Precinct (MMP) represents a focused collaborative intervention that emanated from this multi-stakeholder, consultative process, with an initial focus on hard rock, narrow reefs. It constitutes a pioneer collaboration in mining research, development and innovation (RDI), as all stakeholders, including government, mining companies and local mining equipment manufacturers, the research community, as well as organised labour, acknowledge the need for a coherent, collaborative approach to contribute towards the modernisation of South Africa's minerals sector.

Support of this signalled a renewed recognition of the role of mining by the Department of Science and Innovation (DSI) and highlighted the department's support towards the recovery of the minerals sector and our commitment to contribute towards its modernisation and long-term sustainability.



THE SAMERDI STRATEGY

The Strategy, that was finalised in 2015, was further consolidated and research programmes finalised following further consultation. The strategy is aimed at materially improving the technological base of mining in South Africa and thereby contribute towards the survival of the sector through the mining of lower grades and deeper resources, is a partnership between government (led by the DSI) and the Minerals Council South Africa. This joint RDI programme is co-hosted by the CSIR and the Minerals Council South Africa and is currently one of the largest public-private RDI partnerships, whereby the Minerals Council South Africa matches half of the RDI funds from government, resulting in a total annual RDI budget of close to R100 million.

The mission of SAMERDI is to “maximise the sustainable returns of South Africa’s mineral wealth through collaborative RDI and implementation of mining technologies in a socially, environmentally and financially sustainable manner that is rooted in the local community and national economy. Read more on how the MMP is implementing the SAMERDI Strategy implemented below (or on page xx)

The DSI’s White Paper on Science, Technology and Innovation (STI) aims to position the National System of Innovation to increase the contribution of STI to address South Africa’s development challenges, through a number of policy shifts, including increasing the focus on inclusivity, transformation and linkages in the National System of Innovation, developing a more enabling environment for innovation, expanding the research system, developing human capabilities and increasing investments in RDI.

The DSI’s Decadal Plan continues to emphasise the theme of leveraging RDI to modernise the economy and mining is one of the sectors prioritised in the Decadal Plan.

Cognisant that finding solutions to problems affecting South Africa requires collaborative efforts, one of the core themes of the 2019 White Paper on STI is RDI partnerships. Partnerships with industry are central to ensuring that RDI is relevant and aligned to user requirements, while also addressing national development goals.

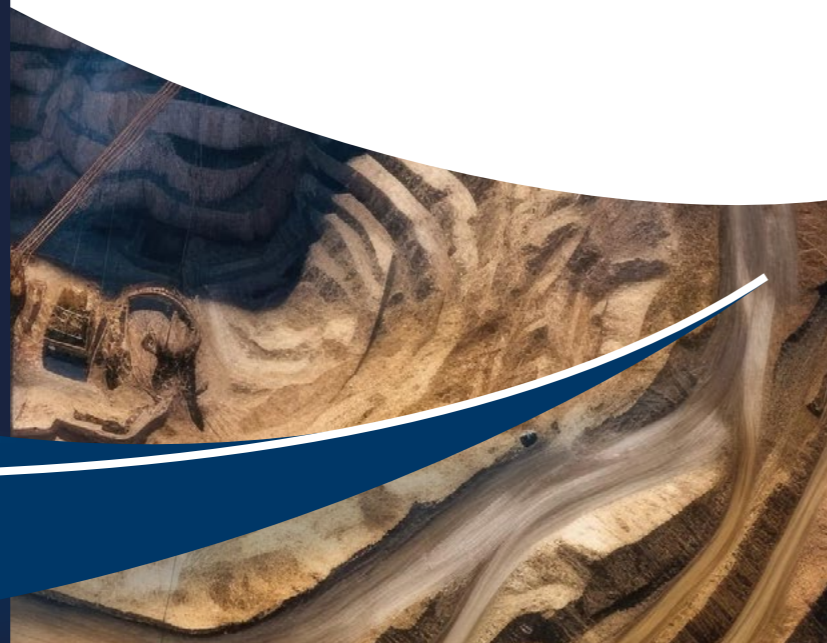
The DSI’s Decadal Plan continues to emphasise the theme of leveraging RDI to modernise the economy and mining is one of the sectors prioritised in the Decadal Plan. The Decadal plan has highlighted additional topics which needs to be considered within the scope of modernising the mining sector, and thereby the SAMERDI strategy is being revised to remain relevant and deliver the most impactful outcomes.

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SAFETY AND HEALTH

Virtual reality transforms the face of training in the mining industry.

The CSIR has developed an innovative competency-based training framework that provides mining trainees with near-real emergency experiences. The solution uses virtual reality (VR) technology to improve the safety of mineworkers through immersive and experiential training on hazardous scenarios. This training framework uses VR to train mineworkers on how to adequately respond to emergencies such as underground fires and explosions. The approach is set to enhance the trainees’ readiness to respond to hazardous underground scenarios such as irrespirable atmospheres, thus contributing to the safety of South Africa’s mineworkers.

The prevailing phenomenon in mining operations has been workers’ inability to adequately respond to the irrespirable atmosphere caused by fires or explosions. The competency-based training thus ensures that the workers are competent in the emergency procedures, which include donning self-contained self-rescuers and proceeding to the nearest place of safety. It also assists workers to know what to expect in instances of emergencies.

The use of VR technology is well established in the mining industry, particularly in the training of machine operators using a VR-enabled simulator of the machine, vehicle or equipment. It is also gaining popularity in training workers in identifying and managing safety risks. The CSIR-developed solution extends the use of VR to include training for emergency response. The utilisation of VR technology contributes positively to productivity and improved safety within the mining sector. The use of an immersive training approach in training for emergency response is a powerful tool to improve preparedness for scenarios that occur infrequently, but with potentially severe consequences.

The CSIR has undertaken roadshows and a pilot programme starting with coal mining operations in 2023 and is extending this to metalliferous mining operations in 2024.



TRACKLESS MOBILE MACHINE SYSTEM TO PREVENT VEHICLE COLLISION

The CSIR has developed a near-real digital risk tool that predicts the performance of systems in support of the mining industry collision prevention for trackless mobile machines (TMM). In compliance with Chapter 8 of the regulations of the Mine Health and Safety Act of 1996 (Act 29 of 1996), the TMM technology is designed to improve mining safety operations in South Africa.

Through the application of 4IR technologies such as digital twin, artificial intelligence, machine learning, and other data analytic

techniques, the TMM technology is well-positioned to support the mining industry's zero-harm and modernisation initiatives. The technology possesses the ability to evaluate vehicle risk interaction and predict optimum scenarios for decision-making in mines. The TMM technology seeks to improve operational efficiency, productivity, safety, cost reduction, and compliance in the sector and supports the mines in implementing overall traffic management strategies.

The CSIR made significant progress in the mining industry by conducting a pilot study of the technology at a South African open-cast mine. The implementation process of the TMM technology project included the usage of traffic management plans, vehicle logs, and event data to perform data analysis and generate insights. These insights encapsulated event detection for compliance and non-compliance, anomalies, unsafe acts, unsafe conditions, and vehicle interaction. This initial project process formed part of risk identification and management to assist the mine in evidence-based decisions that mitigate risk and subsequently improve safety and productivity.

The TMM solution possesses impeccable benefits for the South African Mining sector. Through its application, national priorities such as industrialisation, localisation, and the re-industrialisation of a modern economy are realised. The CSIR continues to work in collaboration with its main stakeholders, the Department of Science and Technology, the Minerals Council, and the Mandela Mining Precinct.



SECURITY

A controlled environment to detect and defend against cybersecurity threats

Cybersecurity is part of the digital age, even in mining operations. The increased threats of data breaches, information sabotage and ransomware attacks are fast becoming prevalent, and organisations have had to find ways to protect themselves against these threats.

The CSIR has developed a controlled and simulated environment for developing cybersecurity skills, as well as for testing. The cyber range provides a platform for individuals and organisations to practice and improve their ability to detect, defend against, and respond to various cyber threats in a secure and isolated setting.

Cybersecurity incidents can have significant consequences, including disruptions to daily operations which can result in financial loss for organisations. A cyber range allows organisations to proactively identify and address vulnerabilities, reducing the risk of downtime and financial losses due to cyberattacks.

A cyber range tailored to the mining sector can simulate scenarios relevant to mining technologies, critical infrastructure, equipment and processes, allowing cybersecurity professionals in the industry to develop specialised skills to deal with industry specific threats. Mining companies can also use the cyber range to train their incident response teams to effectively handle and mitigate incidents.

Situational awareness for mining operations

The CSIR-developed CMORE is an innovative shared awareness and integration platform that addresses the need for situation awareness and collaboration amongst users through the consolidation of information from various sensors and external systems as well as real-time analytics.

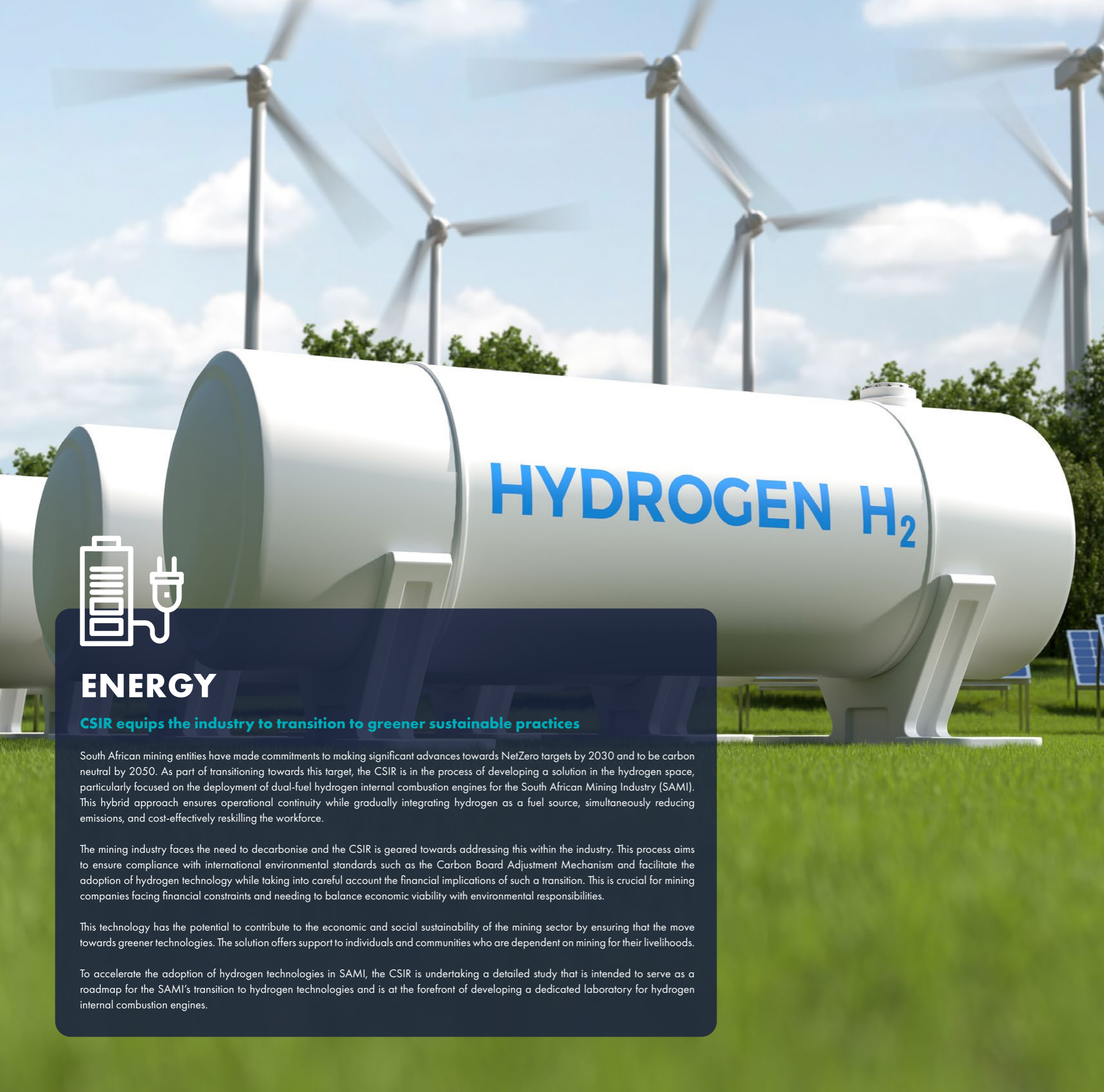
The South African mining industry faces a myriad of challenges in the safety and security of infrastructure – large and small. Monitoring of operations is becoming an integral part of all operations on site. The seamless integration of tools and systems to share intelligence and knowledge to ensure better decision-making and safety has become imperative.

The web-based platform incorporates information from different sources such as cell phones and sensors into a consolidated view that provides operational response managers with near real-time situational awareness. It is a secure, private cloud-based platform with both mobile and web-based applications which are used to view and contribute information to the system.

CMORE provides mine operations monitoring and control teams with situational awareness in a visual format, based on content-rich near real-time state and event information.

CMORE integrates data from various sensors such as cameras, cellphones and seismic sensors. The fusion of these data sources provides a unique capability that allows users to be more responsive to operational, safety and security needs. This enables appropriate responses to be implemented early enough to mitigate negative impacts on safety and productivity.

This consolidated hub presents opportunities to operational managers to make decisions and ensure safety in mining operations.



CSIR'S GROUNDBREAKING HYDROGEN TECHNOLOGY: PAVING WAY FOR SAMI'S GREEN MINING REVOLUTION

South African mining entities have committed to achieving NetZero targets by 2030 and carbon neutrality by 2050. To support this transition, the CSIR is working on a solution in the hydrogen space, specifically focusing on dual-fuel hydrogen internal combustion engines for the South African Mining Industry (SAMI). This approach allows for operational continuity while gradually incorporating hydrogen as a fuel source, reducing emissions, and effectively retraining the workforce.

The CSIR is in tune with the need for decarbonisation in the mining industry and is dedicated to addressing this issue. Our process ensures compliance with international environmental standards, such as the carbon board adjustment mechanism and promotes the adoption of hydrogen technology while considering the financial implications. We recognise that mining companies face financial constraints and should balance economic viability with environmental responsibilities.

Our technology has the potential to contribute to the economic and social sustainability of the mining sector by facilitating a transition to greener technologies. It also offers support to individuals and communities that rely on mining for their livelihoods. To accelerate the adoption of hydrogen technologies in SAMI, the CSIR is conducting an extensive study that will serve as a roadmap for transitioning to these technologies. Additionally, we are at the forefront of developing a dedicated laboratory for hydrogen internal combustion engines.

The use of hydrogen-powered vehicles requires the generation of CO₂-free hydrogen to be meaningful through electrolysis powered by renewable electricity sources (solar PV and wind) and water as a feedstock. It is expected that hydrogen can be generated in this way at between three and seven USD per kilogramme, depending on local solar and wind resources, the weighted average cost of capital, and other factors.

As the South African mining industry strides towards NetZero targets, the CSIR emerges as a crucial ally in this journey. Our innovative dual-fuel hydrogen internal combustion engines promise a seamless transition for SAMI, balancing operational continuity with environmental responsibility. By collaborating with the CSIR, you are not only embracing sustainable practices, but you are also contributing to a cleaner and more efficient future for South Africa's mining industry. Together, let us forge a path to success and establish SAMI as a beacon of green innovation in the mining world.



ENERGY

CSIR equips the industry to transition to greener sustainable practices

South African mining entities have made commitments to making significant advances towards NetZero targets by 2030 and to be carbon neutral by 2050. As part of transitioning towards this target, the CSIR is in the process of developing a solution in the hydrogen space, particularly focused on the deployment of dual-fuel hydrogen internal combustion engines for the South African Mining Industry (SAMI). This hybrid approach ensures operational continuity while gradually integrating hydrogen as a fuel source, simultaneously reducing emissions, and cost-effectively reskilling the workforce.

The mining industry faces the need to decarbonise and the CSIR is geared towards addressing this within the industry. This process aims to ensure compliance with international environmental standards such as the Carbon Board Adjustment Mechanism and facilitate the adoption of hydrogen technology while taking into careful account the financial implications of such a transition. This is crucial for mining companies facing financial constraints and needing to balance economic viability with environmental responsibilities.

This technology has the potential to contribute to the economic and social sustainability of the mining sector by ensuring that the move towards greener technologies. The solution offers support to individuals and communities who are dependent on mining for their livelihoods.

To accelerate the adoption of hydrogen technologies in SAMI, the CSIR is undertaking a detailed study that is intended to serve as a roadmap for the SAMI's transition to hydrogen technologies and is at the forefront of developing a dedicated laboratory for hydrogen internal combustion engines.

SUSTAINABILITY

Sustainable mining: A holistic approach to acid mine drainage management and circular economy transformation

The CSIR emerges as a trailblazer on the African continent in the continuously changing mining arena, managing the difficult challenges of acid mine drainage with its innovative circular economy approach. The CSIR's emphasis on the AMD value chain exemplifies a complete strategy, encompassing AMD treatment and prediction as well as cleanup and sustainable practices. Recognising the limitations of present approaches, such as high sludge output and variable efficacy, we advocate for long-term improved treatment efficiency, effectively offsetting operating costs and boosting resource recovery. The organisation's focus on sustainable AMD practices and bulk supply production demonstrates its dedication to transformational, industry-leading solutions.

The CSIR believes that market analysis must go beyond traditional bounds, investigating the recovery of rare earth elements and minerals from AMD through the lens of circular economy perspectives. The entity presents itself as a thought leader at the nexus of environmental responsibility and economic viability by navigating the complexities of mining waste management market drivers, AMD market overviews, and rare earth elements market dynamics.

The organisation redefines industry norms, based on a pragmatic understanding of the mining industry's difficulties. The CSIR addresses significant environmental challenges by minimising the use of key resources such as water and energy. The adopted approach ensures not only long-term mine closure, but also the establishment of new job prospects, paving the way for mechanisation and innovative industry practices.

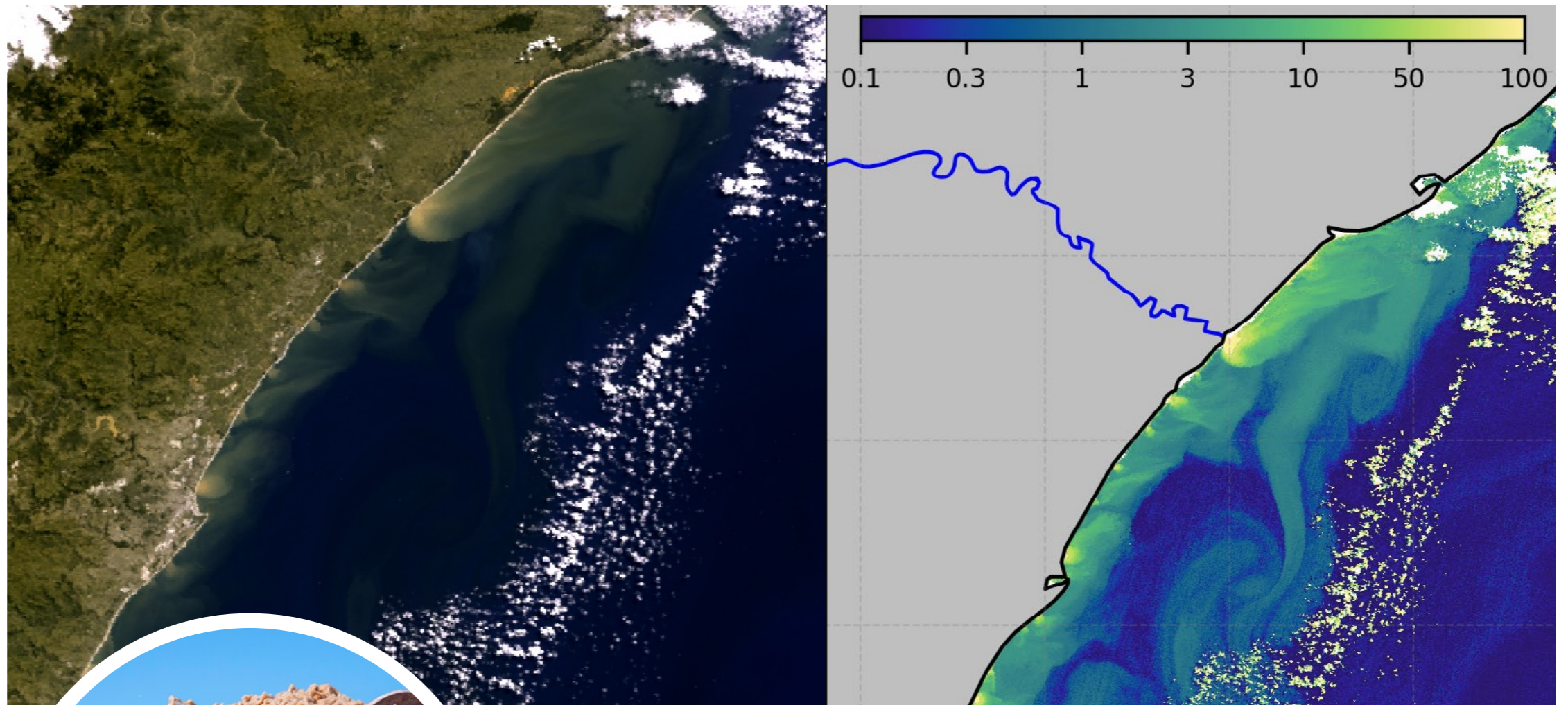
The entity advocates for the generation of food, energy and clean water, aligning its objectives with broader sustainable development goals. By actively seeking collaborative opportunities with other mines and municipalities, the CSIR fosters a sense of industry unity and shared responsibility.

CSIR pioneers laser-based refurbishment for enhanced durability in industrial components

Laser refurbishment or cladding deposits a metallic material onto a surface using a laser beam as the heat source to fuse it to the surface, resulting in a harder and more wear-resistant layer than the base material. Laser cladding and hardening of metal parts for heavy industry and mining are specialised services provided by the CSIR.

Laser cladding and hardening provide wear-resistant coatings that enhance the resilience of critical parts, reducing the need for maintenance. In addition to prolonging the lifetime of new components, these processes are also used extensively to refurbish worn components, especially those that cannot tolerate highly localised heat sources. Such components include turbines, compressors, impellers, generators, pumps, valves and other advanced equipment.

Repairing such components is often more economical than losing production while replacement parts are sourced from abroad. The CSIR has built a track record in repairing these expensive high-wear components using advanced laser cladding and hardening technologies and processes.



The CSIR addresses significant environmental challenges by minimising the use of key resources such as water and energy.

Securing essential ecological assets for African mining with innovative technologies

Critical minerals play an immense role in reshaping the future of mining in Africa. Although the mining industry plays a vital role in South Africa's growth and development, factors such as climate, social and environmental pressures are some of the key challenges faced by the mining sector. This has heightened the need for environmental data and expertise to inform mine planning. Optimal designs and sustainable mining operations, as well as to ensure compliance with regulatory standards and mitigate environmental risks in the mining sector.

To contribute towards South Africa's mining outputs and its potential to grow the economy, as a leading scientific and technology research organisation the CSIR provides a blend of research and application capability in environmental measurement, and observation science to customise solutions for unique difficulties faced in coastal and marine environments, and its impacts in mining. This involves developing and deploying state-of-the-art satellite, remote and in-situ technologies to monitor a range of environmental and biological parameters at various scales in marine and coastal systems with more than over 50 years of experience in this field, and remains at the cutting edge of research, development, and real-world application of these technologies.

When it comes to unlocking the sustainable management of South Africa's precious mineral resources, the CSIR employ mining technology such as the application of environmental measurement, biomonitoring, and specialist ecological science services in the marine and coastal aquatic realms. This is to ensure the protection of the country's ecosystem services and involves:

- Continuous environmental monitoring of mining sites through satellite imagery, in situ instrumentation and discrete field sampling.
- In-house accredited laboratories for low detection limits in marine water, sediment and biological media.
- Specialist Environmental Impact Assessments to evaluate potential impacts on marine, estuarine and coastal freshwater biota, ecosystems, and water quality, ensuring adherence to regulatory requirements.
- Integrating biodiversity considerations in Biodiversity Conservation Plans and strategies to preserve and protect local biodiversity, fostering a harmonious coexistence between mining operations and the environment.
- Sustainability tools to integrate responsible practices into your mining operations, promoting long-term environmental, social, and economic benefits.

The CSIR's Coastal Systems and Earth Observation Research Group leads in this area of work by ensuring that the needs of sustainable mega infrastructure development and resource utilisation, including mining, in coastal and marine areas, are achieved. These efforts continue to enhance the CSIR's science credibility across the African continent.



The CSIR has numerous large metal 3D printers to print critical, large metal parts in a fraction of the time it would normally take to ship them from OEMs.



PRODUCTIVITY THROUGH DIGITAL AUTOMATION

Metal 3D printing offers cost-effective solutions for critical parts, reducing downtime and inventory costs

Metal additive manufacturing, commonly known as 3D printing, involves creating parts layer by layer from digital models, enabling unprecedented flexibility and precision to manufacture difficult-to-machine parts on demand.

Many of the critical parts that fail in the mining industry cannot be repaired. To avoid this, companies need to keep large inventories of extremely expensive parts to reduce downtime. In many cases where inventory is not kept, plants and production lines can be shut down for weeks while replacement parts are sourced from original equipment manufacturers (OEMs) costing mining companies millions of dollars a day in lost revenue.



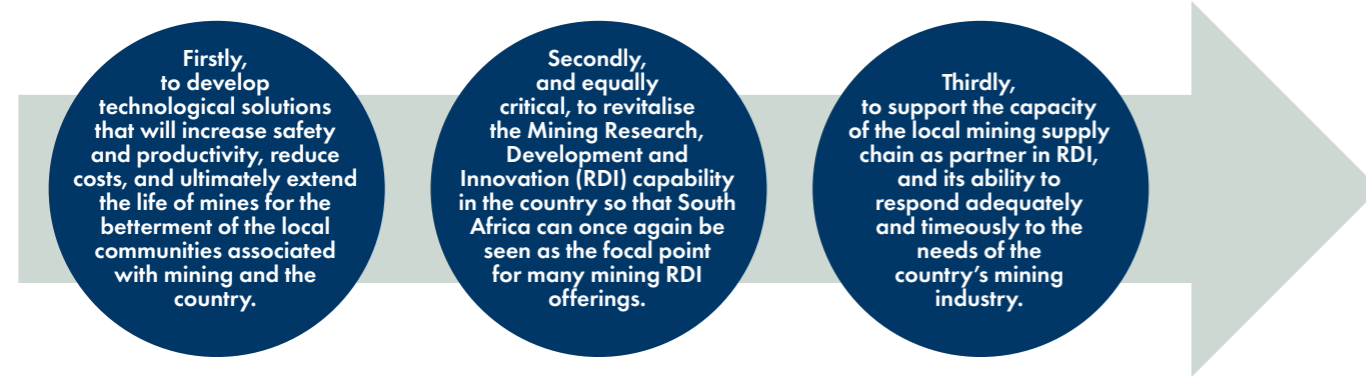
Technologies like metal 3D printing are now so cost-effective that it is possible to apply them to the supply chain in the form of digital distribution of spare parts. The CSIR has numerous large metal 3D printers (up to 600 x 600 x 700 mm³) to print critical, large metal parts in a fraction of the time it would normally take to ship them from OEMs. These machines promise to drastically reduce inventory costs and downtime over the next decade (especially in remote operations)

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THE MANDELA MINING PRECINCT

Why the MMP exists.

The MMP was established to implement the South African Mining, Extraction, Research, Development, and Innovation (SAMERDI) strategy, as set out in the DSI's White Paper on Science, Technology and Innovation. The SAMERDI strategy aims to achieve the following objectives:



South Africa is one of the richest countries in the world in terms of mineral deposits. Mining has been one of the primary contributors to South Africa's Gross Domestic Product. Despite the long history of mining, it is still viewed as a sunrise industry. To address the challenges of mining, such as deeper and narrower ore bodies as well as the need for increased safety, the comprehensive SAMERDI strategy was launched by the Minister of Mineral Resources and Energy, Gwede Mantashe; and the then Minister of Science and Technology, Mmamoloko Kubayi-Ngubane on 14 September 2018.

What we do

The Mandela Mining Precinct is positioned as an enabler for creating technological and people-centric solutions for the benefit of the South African mining industry, the South African Development Community, and ultimately for the benefit of the African continent. The SAMERDI strategy is implemented through five core research programmes that aim to assist the industry in achieving zero harm, job preservation and creation, and increasing efficiencies by focusing on technologies, people and processes. The MMP also delivers on the development of human capacity and capability in the minerals sector, which is a fundamental goal of the SAMERDI strategy.

In addition to developing technologies for increased safety and extending the life of mines, there is a strong focus on developing the next generation of mining equipment and in so doing, strengthening South Africa's manufacturing capability. There is also an increased focus on community development and environmental protection.

These bold and ambitious objectives are well on their way to being realised through the five research programmes of the SAMERDI strategy. The five programmes are:

- 1 Longevity of current mines (LoCM)**, which seeks to improve mining practices and procedures, particularly for established mines already constrained by their infrastructure;
- 2 Mechanised Mining Systems (MMS)**, which provides sustainable mechanised solutions to gold and Platinum Group Metals (PGM) mines by introducing disruptive technologies to facilitate zero harm and achieve financially sound underground mining operations with consistent production at optimal cost;
- 3 Advanced Orebody Knowledge (AOK)** programme provides mine planners, rock engineers, geologists and other decision-makers with information and knowledge that will contribute to the optimal extraction and zero harm objectives.
- 4 Real-Time Information Management Systems (RTIMS)** programme aims to improve data sourcing, transmission, storage, dissemination, and information management tools, practices and procedures for mines; and to assist mining companies on their Fourth Industrial Revolution (4IR) and digitalisation maturity journeys;
- 5 Successful Application of Technology Centred Around People (SATCAP)** programme seeks to understand how people relate to each other, and with technology by considering the impact, effects and challenges that are associated with technology within the sector. This is particularly important given the emergence of 4IR globally.

A collaborative approach is followed whereby the MMP is the hub and a range of research institutions, commercial partners and universities are the collaboration spokes. Strong networks are developed with local and international partners and collaborators to ensure efficient delivery of research and development (R&D) solutions to the industry.





HIGHLIGHTS OF THE STRATEGIC RESEARCH PROGRAMMES OF THE MMP

Longevity of Current Mines (LoCM)

The LoCM programme has grown significantly over the past five years, starting with a focus on production-related activities to modernise or optimise mines. In the latter three years, the focus shifted to sustainability, resource extraction optimisation and technology business improvement. The future of sustainable mining has put an emphasis on providing a safer and healthier mining environment, to turn liabilities into assets. Water treatment and utilisation, environmental impact controls and sustainable energy sourcing are major topics of investigation. Resource extraction remains the primary focus area, underpinned by remote operability and modernisation.

Key project outputs from the LoCM programme was the Isidingo Drill Challenge, which aimed to develop a proven drilling technology utilising an alternative power source to pneumatic drill that is faster, quicker, lighter, and easily manoeuvrable. The Challenge resulted in the completion of the testing of the Hydro Power Equipment (HPE) and Novatek drill prototypes underground. The drills (HPE and Novatek) were manufactured by two local original equipment manufacturers (OEMs), as part of the MMP's industry innovation challenge, the Isidingo Drill Challenge. The first order of 60 Isidingo drills has been received by the manufacturer. The drills are unique in design and allow for effective remote operability, faster drilling, and are more environmentally friendly compared to conventional drills. They are also suitable for women to use in the mining industry.

A second major outcome was a Remote Scraper with proximity detection. The control unit is connected to the scraper winch, which enables emergency shut down when miners are detected in proximity of the winch or the scraper pathway. Two prototypes have been developed thus far.

LoCM has also initiated a Remote-Control Charging Unit. This is a safer explosive charging unit that removes people from the face area while charging the face. It enables charging from different angles and has manoeuvrability to be used in confined spaces.

Mechanised Mining Systems (MMS)

Key project outputs of the MMS programme include diamond wire cutting, which is a rock-breaking method, where the equipment is remotely operated. The equipment is light, safe, easy to use and robust for underground application with an electric wire saw (15kW) for easy operation on heavy-duty cutting jobs with automatic wire tension. Diamond wire sawing can remove only the reef portion without waste, changing the mining operation from a non-profit situation to a profitable one. Diamond wire cutting is remotely operated therefore ensuring that no person will enter the panel because the reef extraction was done from the top and bottom accesses. This method proves to be an alternative to drilling and blasting for removing small block areas with weak hanging wall conditions.

Several guidelines were developed and published before the end of August 2021.

Advanced Orebody Knowledge (AOK)

- The AOK programme focusses on the demonstration and testing of technologies. Underground trials with the support of its Technical Steering Committee (TSC) members, were taken to several mines such as Kroondal (Glencore), Kloof (Sibanye), Tshepong (Harmony), Styldrift (RBPlat), Maseve (RB Plat), South Deep (Gold Fields), Impala 20# (Implats) amongst others.
- Numerous successful underground trials were conducted with Ground Penetrating Radar (GPR) which identified the multiple uses of GPR as a tool to identify lithologies, fractures and geological features. A CSIR methodology for underground application and integration with other technologies has been completed and has been made available to the industry through a guideline report with a training webinar/workshop for further uptake and application.
- From underground trials and work done during the previous years, the Electric Resistance Tomography (ERT) proved to be a useful tool for identifying geological features in a virgin block of ground.
- The Integrated Thermal Acoustic Device (ITAD) can assist miners in detecting a loose rock by using a non-contact thermal camera method to analyse and display the suspected loose rock to the user, which can be further verified using an acoustic method of tapping the rock and analysing the acoustic response. The device is currently in the validation phase and further prototype development has been planned.
- The Au and PGM Resource Atlas and related projects have been concluded and a decision was made to migrate it to the Council for Geoscience (CGS) to allow it to grow and be more sustainable.
- The AOK programme and its projects have been published widely in the media and numerous other platforms which include, Mining News, Modern Mining, African Mining Market and African Mining. Over 100 project reports have been completed by the AOK programme, and have also been disseminated through presentations, summaries and workshops to research institutions, industry, and other stakeholders. Ten technical/conference papers have been reviewed and published on work that has been done under this programme to date.
- A major success has been the collaborative nature of the research, which allowed for a greater pool of knowledge and insight to be exploited in planning and executing the research.

Real Time Information Management Systems (RTIMS)

RTIMS aims to develop and implement smart connected systems for mining from sensor to dashboard. The focus is on ensuring that the right information is sent to the right person at the right time. One of its main thrusts is to equip systems decision-makers with the capability to make informed decisions about future and convergent digital technologies/systems and their value. Some of the key achievements over the past five years include:

- The scalable RTIMS Open Data Analytics Platform (ODAP) and Reference Architecture was designed, developed, and demonstrated. The platform aims to enable the “mining of big data” and the provision for ‘blue sky’ insights from the Artificial Intelligence (AI) capability that is being modelled. It will source real-time data such as vehicle health, mine health and environmental conditions, from a host mine and enable the concept of the “digitalised worker”.
- The completion of the design of a world-class reference architecture and systems engineering approach for Internet of Things (IoT) in mining project would enable integrated and holistic definition of solutions by OEMs and mining companies alike.
- The establishment of the Smart Integrated Mining (SIM) Lab at Stellenbosch University which hosts the digital mesh of intelligent mine-related devices and equipment on a common platform. It addresses the requirements for vendor-agnostic interoperability, redundancy, and connectivity of devices, and enhances real-time processing and management of data where it is required (from edge tier to dashboard).
- The creation of a digital business case validation tool which evaluates the financial and non-financial impact a digital initiative or portfolio of initiatives has at a mine or across an enterprise.





Five 'ESG' people-centred guidelines with tools were developed, with transfer to four mining companies

Successful Application of Technologies Centred Around People (SATCAP)

SATCAP has delivered a range of research reports, guidelines, exemplar training modules, ESG/People-Centred tools and several Study Tours over the past five years. As mines modernise, addressing the environmental, social and governance (ESG) agenda becomes more urgent. To lend support to mines in this regard, SATCAP has recently focused on ESG projects, with the consideration of social/community-related aspects. Five 'ESG' people-centred guidelines with tools were developed, with transfer to four mining companies: Sibanye Stillwater, Harmony Gold, RB Plat and Impala. The Guidelines offered included:

- Training-Needs Assessment for Mining Modernisation,
- SMME Communications Solution,
- Community Social-Needs Assessment Tool,
- Digital Leadership Competencies Assessment, and
- Change Management Blueprint.

Other projects that the SATCAP embarked on include:

Immersive Study Tours: In order to create awareness, understanding and acceptance for mining modernisation, SATCAP conducted stakeholder immersion study tours to mining universities, mines, and modern training entities. Stakeholders were immersed in modern mining through interactive activities and experiences at the Wits DigiMine, UP's Virtual Reality Centre, UJ's mock mine, South Deep gold mine, Murray and Roberts Training Academy, and the Wits Tshimologong (digital innovation entrepreneurship hub).

Capacity Building: workshops were also held to support capacity building for mining students, interns, researchers and trade unions. These included: **Supervisory Leadership Development, Digital Literacy, Change Management and Human Centred-Design.** A Women Empowerment session was also held.

Immersive study tours

Four 'art of possible' exemplar training modules were developed and demonstrated to showcase modern skills development/training to support modern mining. These included a supervisory leadership development exemplar module to support supervisors in leading and driving mining modernisation; a digital literacy exemplar module to support enhancing the Adult Education Training (AET) programme/community youth portable skills; a virtual reality (VR) training solution for miner's upskilling to support healthy and safe production; and an augmented reality (AR) training simulation for Rock Drill operators and miners upskilling.

Underground Test Facility/Test Mine

The MMP has embarked on a journey to establish an underground industry Test Mine facility to facilitate industrial training, technology demonstration, and technology incubation. The MMP has done substantial work realising this facility over the past two years, including obtaining the use of a test site facility on an active mine at Royal Bafokeng Platinum near Rustenburg. A marketing and financial feasibility study was completed, and the mining industry gave its support for the development of the Test Mine. Design plans were drawn up and surface construction has been initiated.

The main objectives of the facility are:

- To provide a site for practical low to medium-risk research and development associated with the MMP, MEMSA, OEM's, mining companies, universities, research organisations and the SAMERDI programmes.
- To provide an industrial environment that mimics a real underground mine for all suppliers of mining equipment, MEMSA members and other suppliers, to conduct low to medium risk tests and prove their technologies.
- To provide a site for low to medium risk technology and use case demonstration by OEMs and other suppliers.
- To develop a site for technology incubation.
- To have a site that is desired by both the buyers of innovation and the builders of innovation.
- To provide an "active living laboratory" for the sector.
- To provide a site for professional and industrial training, government certificates, and state-of-the-art training on new technologies.
- To provide a site for university students to conduct practical training and research.
- To showcase new technology developments to the mining sector.
- To provide for awareness-raising and other minerals-related education activities.

The MMP has embarked on a journey to establish an underground industry Test Mine facility to facilitate industrial training, technology demonstration, and technology incubation.



OUR VALUES



INTEGRITY

- Our actions reflect consistent and uncompromising adherence to strong moral and ethical principles and values. Solid as a rock.

INNOVATION

- The golden thread is our proven track record of excellence and coming up with new ideas that solve real problems, safely.

PEOPLE-CENTRICITY

- Our wealth lies in the calibre and quality of our people. We respect, care for and accept others and bring out the best in each other.

PARTNERSHIPS & COLLABORATION

- We attract likeminded peers who share our objective for impact and making a difference. Relationships start with you.



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