

COAL

INTERNATIONAL

Volume 273 • Number 6

November-December 2025



m martin
engineering



Tradelink Publications Ltd

Publishing, Printing & Website Services for the Mining Industry

All issues of Mining & Quarry World & Coal International are free to download



COAL
INTERNATIONAL

**MINING & QUARRY
WORLD**

2026 Editorial Programme

To receive your copy of our 2025 media pack please contact
gordon.barratt@tradelinkpub.com
+44 (0)1777 871007 / +44 (0)7506 053527
alternatively download from our web site www.mqwworld.com

News, Plant and Equipment

Features

12 Writing a smart inspection plan

16 Underground mining in the age of innovation: technology, safety, and sustainability

27 From Maintenance Mode to Market Necessity

30 Who holds the purse strings? Understanding mining procurement power

32 From the pulpit to the picket line: For many miners, religion and labour rights have long been connected in coal country

40 Titans of Earthmoving: dragline excavators in mining

45 Electric and Hybrid Machines: changing the way we mine



Martin Engineering

Decades of experience allow us to provide you with a cleaner, safer and more productive operation.

Managing Director and Publisher: Trevor Barratt
International Sales: Gordon Barratt +44 1909 474258 gordon.barratt@tradelinkpub.com
Graphic Designer: Sarah Beale sarah@g-s-g.co.uk

Published by: Tradelink Publications Ltd.
16 Boscombe Road, Gateford, Worksop, Nottinghamshire S81 7SB

Tel: +44 (0)1777 871007
Fax: +44 (0)1777 872271
E-mail: admin@mqworld.com
Web: www.mqworld.com

Copyright© Tradelink Publications Ltd. All rights reserved.



China's emissions have been trending down for 18 months

For 18 months, China's carbon emissions have been flat or falling as solar and wind displace coal and electric vehicles supplant gas-powered cars. That is the finding of a new analysis, which comes as China takes center stage at the U.N. climate negotiations now underway in Brazil.

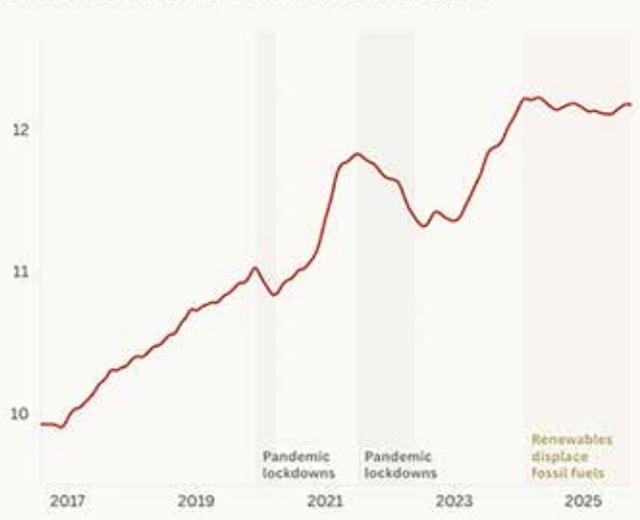
China, the world's biggest emitter, has only previously seen its emissions drop during economic downturns, as during the coronavirus pandemic. This is the first time that the buildout of clean energy is largely driving the decline, experts say.

Emissions from the power sector stayed flat even as demand grew, while emissions from cars declined as drivers switched to electric cars, according to the new analysis from Carbon Brief. A recent downturn in construction is also blunting emissions from the production of steel and cement.

As wind and solar gain steam, the average coal plant is producing less power. The declining use of coal could "prompt a rethink" of plans to continue building out coal power plants, according to the analysis.

China has previously seen

China's Emissions
Billion tons of carbon dioxide from fossil fuels and cement



its emissions drop during economic downturns. Now, for the first time, the growth of renewables is driving the decline. Source: Lauri Myllyvirta. Yale Environment 360

China is likely to see an overall drop in emissions in 2025, and if trends continue, it will hit "peak" emissions several years ahead of its target. Chinese leaders have committed to seeing emissions crest before 2030.

Declining emissions mean China "won't need to be as defensive in international negotiations," Lauri Myllyvirta, author of the new analysis, recently told Yale Environment 360.

"I think that will translate into a much more constructive and solutions-oriented approach."

China is already the biggest exporter of clean tech globally and a major backer of renewable energy projects beyond its borders. As the U.S. retreats from the fight to stem warming, China is set to become the driving force in climate diplomacy as well, Isabel Hilton writes in an analysis for Yale E60.

China "is staking its claim to leadership," she says, "both as the steady and reliable partner in the global energy transition and the primary purveyor of the means to achieve it."

COP30 seals uneasy climate deal that sidesteps fossil fuels

Brazil's COP30 presidency pushed through a compromise climate deal recently that would boost finance for poor nations coping with global warming but that omitted any mention of the fossil fuels driving it.

In securing the accord, Brazil hoped to demonstrate global unity in addressing climate change impacts even after the world's biggest historic emitter, the US declined to send an official delegation.

Acknowledging that the deal left many frustrated, the head of the UN climate secretariat (UNFCCC) praised the delegates for coming together in a year of denial and division.

"I'm not saying we're winning the climate fight. But we are undeniably still in it, and we are fighting back," UNFCCC Executive Secretary Simon Stiell said in a statement.

The agreement, which landed in overtime after two weeks of contentious negotiations in the Amazon city of Belem, exposed deep rifts over how future climate action should be pursued.

After gaveling the deal through, a weary Brazilian COP30 President Andre Correa do Lago told delegates he recognized the talks had been tough.

"We know some of you had greater ambitions for some of the issues at hand," he said.

Several countries objected to the summit ending without stronger plans for reining in greenhouse gases or addressing fossil fuels.



Inland market urgently needs reforms, conference hears

South Africa's inland coal market faces a critical need for reform, with inconsistencies in supply, declining coal quality and logistical bottlenecks threatening the reliability of the fuel that underpins much of the country's industrial activity, OPack Network Holdings MD and marketing director Gavin Boyes has said.

Speaking at a coal industry colloquium hosted by advocacy organisation FFF Carbon, in Johannesburg, on November 7, he highlighted the pressure on inland users of coal, who accounted for only 4% of South Africa's total coal production.

"Most of our coal production is earmarked for the export market, chasing higher returns on the global stage. That means the inland market is left with irregular, inconsistent supply," he said.

Boyes added that the absence of new mining operations aimed at local consumption had exacerbated the problem, leaving industries reliant on batches of run-of-mine coal sold to traders.

Boyes described the logistical challenges facing the inland coal market as a major contributor to rising costs and inefficiencies. He said rail transport was constrained by maintenance backlogs, a shortage of locomotives and wagons and a prioritisation of export shipments.

"Railway infrastructure is indeed struggling, as we all know, maintenance backlogs have led to trains sitting stationary for up to six weeks at a time, locomotives and wagons are in short supply. Export consignments take priority over inland deliveries, and there is no space or spare capacity in the current system," he said.

With rail unable to meet demand, many suppliers

relied on road transport, which presented its own challenges. Boyes noted that a shortage of return loads forced hauliers to pay premiums of 40% to 60% for empty trips, while limited reliable hauliers, long transit times and insufficient road capacity further constrained coal distribution.

He pointed out that it could take up to four days for a truck carrying coal from Mpumalanga to reach its destination in the Western Cape – a significant time delay that coal buyers could ill afford.

Declining coal quality was another concern, Boyes said, noting that this affected both calorific value and integrity. He described the impact of blending lower-grade coal with higher-quality batches, warning that it could reduce efficiency, increase emissions, raise maintenance costs, and sometimes cause permanent equipment damage.

"You cannot blend coal in a way that preserves its original quality. What often happens is that a batch of high-grade coal is mixed with low-grade product from various sources, creating product that looks good on paper but performs poorly in practice," he said.

Prices have also risen sharply in recent years, Boyes

added, noting that local coal costs increased by about 45% between 2021 and 2024. Logistics costs for rail rose an average of 9% a year, with a 45% increase over the last five years, and road transport costs increased by about 6%, largely owing to diesel prices set by the Department of Mineral and Petroleum Resources.

"Because local prices are linked to the Australian Price Index parity structure, end-users face a cruel irony: when export prices fall, inland prices often remain the same," he said.

Boyes stressed the effects on industrial end-users, saying that procurement officers and engineers often lacked the detailed knowledge to make informed coal purchasing decisions. Misplaced trust in suppliers can result in the purchase of low-quality coal marketed as premium.

"End-users buy what they think is a grade, only to find out that C-grade is C-grade dressed up as premium blended coal. It damages boilers and reduces efficiencies, and legitimate resellers are forced to compete with artificially cheap, poor quality products. Ultimately, it's the end-user who suffers most with painful

repairs, maintenance costs and inefficiencies," he said.

To address these challenges, Boyes outlined several proposed reforms, including allocating a portion of production to the inland market, exploring cross-border sourcing, establishing central distribution hubs, overhauling the rail system, and implementing standardised quality control measures.

He also advocated for a domestic pricing model independent of export parity, fixed inland discount rates set yearly, and education for end-users on coal sampling, testing and boiler efficiency.

"The inland coal market is too important to fail. Without coal, much of the inland industry would grind to a halt, but without reform, the market will collapse under its own inefficiencies and bad practices.

"Our choice is clear: either we fix the system together, or we watch it erode piece by piece. Coal is still crucial. It will remain a cornerstone of South Africa's inland economy for decades to come, but it must be managed, regulated and delivered in a way that ensures fairness, protects the end-user and embraces environmental responsibility," Boyes said.



Trump Administration adds metallurgical coal to critical minerals list

The US added uranium, copper and silver to a government list of critical minerals as the Trump administration broadens its scope of what commodities it deems vital to the American economy and national security.

The updated US Geological Survey list also adds metallurgical coal,

potash, rhenium, silicon and lead, according to the list posted to the US government site. The list replaces a 2022 version.

The list dictates what commodities are included in the Trump administration's Section 232 probe into processed critical minerals and derivative products announced mid-April, which

could lead to tariffs and trade restrictions. President Donald Trump has made it a priority to bolster domestic supply of these minerals, arguing that overreliance on foreign supplies jeopardises national security, infrastructure development and technological innovation.

The list also informs direct investments in mining and resource recovery from mine waste, stockpiles, tax incentives for US mineral processing as well as streamlined mining permitting.

The resource industry had been pushing for certain metals and minerals, like copper and potash, to be included on the list. Much of the potash used in the US

is shipped from Canada, which accounts for roughly 80% of imports of the mineral. Copper imports, meanwhile, comprise almost half of total US consumption and come from countries including Chile, Peru and Canada. The bulk of global copper refining is done in China.

Silver's inclusion has been a concern for precious metals traders and manufacturers that rely on the material. Any tariffs on silver could wreak havoc on the metals markets because the US relies heavily on imports to meet domestic demand. Silver has wide industrial applications and is used in electronics, solar panels and medical devices.



How FLS is reimagining mine waste management

Across the globe, miners are re-examining what waste really means. Tailings, once written off as liabilities, now hold the potential to deliver new revenue streams, critical minerals, and major environmental gains.

For more than 140 years, FLS has provided the technology, knowledge and services that empower customers to meet complex operational challenges.

In recent years, many of those challenges have focused on minimising environmental impacts. FLS's long-standing and proven legacy of innovation has enabled the company to be at the forefront of driving efficiencies while delivering sustainable outcomes.

With governments tightening regulations on tailings storage and the demand for metals

accelerating, the pressure is on to extract more value from less material, while ensuring that mine operators achieve their environmental, social and governance (ESG) goals.

"Every mine has hidden value sitting in its tailings," FLS business development manager for REFLUX technologies Anson Gilbert said.

"The challenge has always been to recover that value efficiently, safely and at a scale that makes economic sense. That's exactly where our REFLUX technology family steps in."

lamella plates. The plates accelerate the settling of dense particles while desliming and classifying fine material. The result is a sharp density-based separation with exceptional throughput.

Developed in partnership with Laureate Professor Kevin Galvin at the University of Newcastle, the REFLUX Classifier family – including GradePro and the REFLUX Flotation Cell (RFC) – combines gravity separation, classification and flotation principles to recover value from fine and low-grade feeds.

Originally designed for coal, the RC now operates successfully in iron ore, base metals, manganese, chromite, mineral sands and spodumene. The technology is applied in more than 200 installations worldwide.

Redefining beneficiation

At the heart of FLS's solution is the REFLUX Classifier (RC), a compact gravity separator combining a fluidised bed with a system of closely spaced inclined



According to FLS, tests in Canada and Brazil have shown 20% higher recovery and Fe grades exceeding 63% in a single stage, replacing complex multi-stage flotation circuits. In coal and iron ore applications, the RC's lamella design has delivered probable-error (Ep) values below 0.06, said to be more than double the precision of traditional spirals.

Building on this foundation, FLS released the REFLUX Classifier Concentrator (RCC) – now marketed as GradePro, an advanced version tailored for low-grade ores and tailings re-treatment. The GradePro integrates secondary fluidisation water and a smaller mixing chamber, cutting bed-build times by a factor of seven and increasing upgrade ratios more than 30 times for tin and tantalum tailings.

“GradePro takes all the learnings from the RC and adapts them for the world of low-grade feeds and mine waste,” Gilbert said. “It’s robust enough for plant operation, but selective enough to recover fine, high-value minerals that other devices simply miss.”

The REFLUX Classifier family includes Grade Pro and the REFLUX Flotation Cell. Image: FLS

From tailings to treasure

FLS said recent pilot campaigns underscore the step change. At a tin operation treating 0.15% Sn tailings, the GradePro achieved 447× tin upgrade (67% tin product grade) with over 75% recovery.

In Brazil, it was demonstrated that a simplified SAG – RC circuit can replace traditional flotation, reducing operating expenditure by 42% and capital expenditure by

five% while maintaining of more than 68% Fe concentrate.

Meanwhile, in Canada, the RC has delivered consistent high-grade iron ore concentrates with outstanding recovery and stability.

“Every one of these projects proves that you don’t need more stages; you just need smarter separation,” Gilbert said. “The REFLUX approach achieves cleaner cuts, smaller footprints and faster payback.”

Recovering value is only half the story. Managing what remains is equally important.

FLS’s AFP2500 automatic filter press complements the REFLUX technologies by producing stackable, low-moisture tailings that can be safely stored or repurposed as backfill. Together, the technologies form a closed-loop system: recover the metals, recycle the water, and drastically reduce tailings dam volumes.

“This integration aligns perfectly with our MissionZero commitment,” Gilbert said.

MissionZero is FLS’s sustainability program that aims to reduce emissions and waste in mining to zero by 2030. In adopting the commitment, FLS has endeavoured to offer its customers the required technological and digital solutions to move towards greener mining processes.

“We’re helping customers move toward dry-stacked, resource-positive operations, where tailings dams become a thing of the past,” Gilbert said.

Of course, the shift to a more sustainable world is further driving demand for minerals like copper, lithium, and other critical minerals.



These critical minerals are foundational to the global green transition because they enable the technologies driving decarbonisation.

Copper is vital for renewable power and electrification. Its superior conductivity makes it indispensable in wind turbines, solar panels, electric vehicles (EVs) and power grids.

Lithium is central to energy storage, forming the core component of lithium-ion batteries that power EVs and balance renewable energy supply through grid-scale storage systems.

Beyond these, minerals such as nickel, cobalt, rare earth elements and graphite are equally important.

These minerals underpin the infrastructure of a low-carbon economy – renewable energy systems, electric mobility and advanced storage technologies.

Growing research points to rare earth and critical mineral recovery from coal and historic tailings.

The GradePro’s ability to separate on subtle density differences makes it suitable for extracting fine rare earth elements bearing phases, further extending its relevance as the energy transition accelerates.

“Critical minerals are the new frontier,” Gilbert said. “The chemistry is complex, but the physics of separation still matters, and that’s where our technology gives miners an edge.”

A circular future for mining

Corporate governance and ESG compliance have become mandatory expectations; however, many companies still grapple with the challenges of how they can reconfigure operations for long-term sustainability.

As mining companies face increasing ESG expectations, technologies that turn waste into resources are reshaping the industry narrative.

By combining scientific innovation with proven field performance, FLS’s REFLUX technologies can offer economic viability, environmental responsibility and operational simplicity in one platform.

“The conversation has shifted,” Gilbert said. “It’s no longer just about compliance or waste management; it’s about value creation, decarbonisation and future-proofing our industry. REFLUX technology allows us to do all three.”

Polish government approves bill facilitating mine closures and compensation for miners

Poland's government has approved a bill intended to support the transition away from coal by allowing mines to be closed down more easily, introducing financial support for miners who lose their jobs, and helping redevelop former mining areas.

"This is a specific response to the challenges of the energy transition and provides real support for thousands of miners," said energy minister Miłosz Motyka. "We want the process of change to be carried out responsibly, with respect for local communities."

Poland is Europe's most coal-dependent country, with the fossil fuel accounting for 57% of power generation last year. While there has been a gradual shift away from coal, this has been accompanied by concerns about the impact it will have on coal-mining regions.

Motyka says that the newly proposed measures – which must still be approved by parliament and the president – "pave the way for a just transition in mining regions", providing "a stimulus for investment

and development, and the creation of new jobs".

The legislation would allow mining companies to decommission mines independently but with state financial backing. They can also transfer such assets as donations to local authorities or state entities, allowing them to be used for investments, revitalisation projects or infrastructure construction.

The bill would also introduce a package of protective benefits for workers at companies that are closing mines, including severance payments of 170,000 zloty (€40,000)

The proposed law would also introduce rules to prevent state subsidies for reducing production capacity from being used mainly to cover mining companies' operating costs instead of cutting output, reports news service WNP.

While the government has a majority in parliament, the bill could face a veto from opposition-aligned President Karol Nawrocki, who during



his campaign for this year's elections called coal "black gold" and pledged to ensure that Poland continues to produce "cheap energy from coal" mined domestically.

Poland's mining sector has been struggling in recent years. Polish coal is among the most expensive in the world to get out of the ground. Burning it causes a lot of emissions that bring costs under the EU Emissions Trading System.

Newly released Eurostat data show that Polish households have the EU's third-most expensive electricity, when taking countries' costs of living into account.

But Poland's coal industry – with its long history and powerful unions – has long enjoyed political influence

and public support. It is propped up by the state: to the tune of 9 billion zloty this year and an estimated 5.5 billion in 2026.

According to the energy ministry's impact assessment, the cost of closing hard coal mines under the new bill over the next decade will reach 11.3 billion zloty.

Jastrzębska Spółka Węglowa (JSW), which is the EU's largest producer of coking coal, has made headlines recently after the company reported that, in the first half of the year, it recorded a loss of over 2 billion zloty.

That followed a record loss of 7.3 billion zloty last year and raised further concerns about JSW's financial viability and the potential need for further state support.

Some state-owned power producers are already cutting their reliance on coal by offering generous severance packages to workers.

Recently, a subsidiary of state-controlled utility PGE, the country's largest electricity producer, reached an agreement with trade unions to close one of its coal-fired power plants, offering €59 million compensation package to workers.



Trump administration issues third order to keep west Michigan plant running

A west Michigan coal power plant will remain open for another three months under a new order from the Trump administration.

The U.S. Department of Energy argues parts of the Midwest are facing an energy emergency, and that the J.H. Campbell coal-fired plant's power would help keep costs low.

Consumers Energy, which operates the plant, had planned to shut it down in May – an early decommissioning the company said was aimed at reducing costs for customers, lowering greenhouse gas emissions, and moving toward natural gas and renewable energy sources.

In a press release, Energy Secretary Chris Wright alleged work taken to shut down coal-burning plants in favour of natural gas and renewable power created an energy shortage.

"The Trump administration will keep taking action to reverse these energy subtraction policies, lowering energy costs and minimising the risks of blackouts. Americans deserve access to affordable, reliable and secure energy regardless of whether the wind is blowing or the sun is shining, especially in dangerously cold weather," Wright said in the statement.

This is now the third time Wright ordered the Campbell plant to stay open.

The last two orders also claimed emergency conditions required the plant to stay open. The most recent one would have expired on Wednesday.

Environmental groups



and Michigan's state utility regulator have pushed back against the Trump administration's reasoning to keep the plant open longer.

Michigan League of Conservation Voters spokesperson Nick Dodge said Campbell's closure doesn't create any emergency.

"It's unnecessary, and there have already been plans and additional generation put in place through renewables and in natural gas to fulfill all the energy needs that Campbell provides," Dodge said.

He also raised concerns about threats to the environment along the Lake Michigan shoreline where the coal-burning plant sits. Regarding the reasoning that Wednesday's order was a cost-saving measure, Dodge said it would have been cheaper to let the plant close.

"It was supposed to save us \$600 million ... through 2040. And that was due to the plant being so inefficient and expensive to operate. So, all of that is out the window now with

the plant being forced to stay open," Dodge said.

Consumers Energy, Michigan's second-largest utility, announced plans to close the Campbell plant back in 2021. The Michigan Public Service Commission approved the plan in 2022.

A webpage detailing steps in the closure said it would make Consumers, "a cleaner, leaner and flexible energy company."

Company spokesperson Katie Carey provided the following statement responding to Thursday's order to keep the plant open.

"Consumers Energy is prepared to continue operating the Campbell plant as required by the U.S. Department of Energy. Consistent with a Federal Energy Regulatory Commission (FERC) order, the costs to operate the Campbell plant will be shared by customers across the Midwest electric grid region – not solely by Consumers Energy customers. We are planning to submit a cost recovery filing to FERC later this year outlining net costs to operate the plant

during the first 90 days."

Michigan shares a power grid with all or part of 14 other states and one Canadian province. The Midcontinent Independent System Operator Inc., or MISO, oversees that regional system.

In a written statement, MISO said it will work with Consumers Energy to ensure order compliance.

"MISO remains focused on reliably operating the grid using the resources our members provide, while working closely with stakeholders and regulatory partners," the statement from MISO media relations advisor McKenzie Barbknecht read.

Michigan energy policies passed in 2023 require the state to rely solely on "clean energy" by 2040.

Despite that, it's possible the Trump Administration could continue keeping the Campbell plant running after February 17, when the current order expires. But it would likely face continued pushback from both environmental groups and the state attorney general's office, which sued over the matter in June.

NSW Government launches coal future authority

The NSW Government has introduced the Future Jobs and Investment Authority to support coal-producing communities and the mining sector.

The authority will work with government, industry and local communities to attract investment, create jobs and manage mine transitions.

“Our coal regions have powered NSW for generations,” NSW Minister for Natural Resources Courtney Houssos said. “Now, we’re investing in their future by helping workers gain new skills and seize opportunities in a growing, diversified economy.”

“Coal mine workers are the backbone of regional coal communities. The

authority ensures their needs are front and centre as we build a stronger future for coal-producing communities.”

Coal is NSW’s top export, with around 40 mines across the Hunter, Illawarra, Central West, and North West regions supplying 90% of production and exports to nearly 30 countries. The sector generates \$2.7 billion annually through economic activity and royalties while supporting thousands of regional jobs.

The legislation, developed after extensive consultation with unions, industry bodies, councils and community groups, includes local divisions in each coal region to reflect local priorities.



Coal mine operators will be required to provide at least three years’ notice before closures and outline workforce support plans, helping communities and workers prepare for transitions. Failure to comply could result in financial penalties.

“The authority will drive investment and create new opportunities, supporting new jobs and industries that will sustain regional communities,” Houssos said. “Thank you to everyone who

was part of our consultation process. Getting this framework right is critical to ensuring coal regions have the support they need into the future.”

The authority is backed by a \$27.3 million investment over four years, with an additional \$110 million allocated to fund projects.

Annual reporting to parliament and a statutory review after three years will ensure the body remains accountable and responsive as the coal sector evolves.

US coal power plants must stay online for as long as possible to meet AI demand – Southern Company CEO

Coal-fired power plants in the US must be kept online for as long as possible to help meet the soaring energy demands of AI data centers, Chris Womack, CEO of energy utility Southern Company, has said.

At Schneider Electric’s North America Innovation Summit 2025, which took place in Las Vegas recently, Womack told delegates that his firm must “make sure we utilize all of the resources available to us” to cope with rapidly increasing energy demand across the US, which is being driven by the AI data center build-out.

He said: “We’ve got to build a lot of natural gas, be that combined cycle or combustion turbines. We’re going to extend coal plants as long as we can because we need those resources on the grid.”

Womack has previously

commented that he would be open to prolonging the life of the firm’s coal power stations, despite the polluting nature of the fossil fuel-burning facilities.

Speaking in 2024, he said coal plants operating for longer was a “consideration” for the firm. It had planned to close most of its coal-fired fleet by 2028 and exit coal-fired generation by 2035. Womack argued at the time that any extension would not impact Southern Company’s plan to reach net zero by 2050.

In February, it was reported, though not confirmed, that the firm could extend the life of its coal plants, which are located in Mississippi and Georgia, and generate 8.2GW until 2039.

US utility companies considering the future of their coal-fired power stations

will have noted comments from Energy Secretary Chris Wright, who said at an event in September that he expected the retirement of coal facilities to be delayed.

Wright’s department formalized its pro-coal stance in October, with the launch of a \$625m fund to retrofit and recommission old coal power stations.

“Beautiful, clean coal will be essential to powering America’s reindustrialisation and winning the AI race,” Wright said.

Coal is widely recognized as one of the most polluting fossil fuels, creating 970 tons of greenhouse gas emissions per 1GWh of energy generated, compared to 720 tons for oil and 440 tons for natural gas.

Currently, the US has approximately 190GW of coal-fired capacity

operational. These plants provided 16% of US energy in 2023, according to figures from the Energy Information Administration.

Womack said his company intends to build 10GW of power infrastructure between now and the end of the decade, investing in sustainable technologies such as battery storage and solar power. He also told the Innovation Summit that growing the US nuclear power fleet would be key to the future of the nation’s grid.

“We’re going to have to build more nuclear, we’re going to need more partnerships with customers and government,” he said. “I think this country should be building another 10GW of nuclear in the next couple of years, to have it online by the mid-2030s to meet this growing demand.”

What does South Korea's decision mean for Australia?

South Korea's pledge to close 40 coal-fired power plants by 2040 could create the potential for increased exports of Australian critical minerals, green iron and aluminium, and other future-facing commodities.

South Korea's decision was announced by its climate minister Kim Sung-hwan at the United Nations' COP30 climate summit in Brazil. The announcement was made as part of South Korea's commitment to joining the Powering Past Coal Alliance (PPCA).

As Australia's third-largest thermal coal export market, South Korea's announcement will have a significant effect on Australia's coal industry; however, the fact the phase-out will be staged over the next 15 years gives coal businesses time to plan ahead.

In addition, South Korea is one of Australia's largest trading partners, and the countries already have agreements in place fostering the development

of clean energy industries and critical minerals trade.

In 2020, the countries signed the Critical Minerals Supply Chain Cooperation Memorandum of Understanding (MoU) and the Low and Zero Emissions Technology Partnership Implementation Plan. These agreements have laid the foundation for advancing bilateral cooperation on critical minerals and clean energy solutions.

One key area of opportunity is supplying South Korea's electric vehicle (EV) manufacturers and battery industry with the range of raw and processed inputs these sectors require in high volumes.

Recognising the ongoing need for these inputs and a secure supply chain, South Korean companies have over the past five years invested heavily in joint ventures with Australian mining companies across mineral exploration, extraction and processing, including lithium, cobalt,



manganese, nickel, phosphate, graphite and other rare earths.

Mineral Resources (MinRes) recently struck a landmark deal with major South Korean conglomerate POSCO, giving it a 30% stake in MinRes' lithium business and cementing the future of two of Australia's top lithium mines.

Queensland Pacific Metals (QPM) shareholders include global battery manufacturing leader LG Energy Solution (LGES) and POSCO, and the company has secured binding offtake agreements for the sale of nickel and cobalt to both.

POSCO and Pilbara Minerals have also undertaken a joint venture, opening a lithium hydroxide facility in South Korea last year, with POSCO owning

82% and Pilbara Minerals the remaining 18%.

Arafura Rare Earths signed a binding offtake agreement with Hyundai Motor Company and Kia Corporation in 2022 to supply NdPr (neodymium and praseodymium, in the form of NdPr oxide or NdPr metal) sourced from its Nolans Project.

These are just a few examples of the extensive list of deals, joint ventures and collaborations between South Korea and Australia.

With strong government frameworks already in place and deep commercial ties established, South Korea's decision to transition from coal holds the potential to further boost Australia's growing sustainable and critical minerals industries.





Writing a smart inspection plan

Like most business plans and strategies, an inspection plan should be built top-down. It should begin with a clear statement of corporate goals and objectives related to asset management. This approach is addressed in ISO 55001 on asset management. ICML 55, the global standard by the International Council for Machinery Lubrication, addresses optimised management of lubricated assets and is aligned with ISO 55001 guidelines. It covers inspection plans. The following refers to developing plans for Inspection 2.0, bringing inspection to a level as high or higher than condition monitoring technologies often used concurrently.

A full-on Inspection 2.0 plan should be a detailed and comprehensive document to ensure that key features and functional elements are not overlooked. From there, it can be abridged or streamlined for quick, readable review by technicians and operators. The unabridged version of the plan can also serve as a rough curriculum for training and competency testing for current and aspiring new inspectors.

Modern reliability and asset management programs expect documented, procedure-based work plans. This reduces the risk of variability, uncertainty and drift over time. The plan is best if it is consensus-based and should be continually improved. Before considering the input of stakeholders in writing the inspection plan, it is best to get everyone on the same page through training or self-study on the fundamental elements of Inspection 2.0 and condition-based maintenance. Of course, RCM, TPM, and asset management training would also be helpful.

Consensus-based inspection plans tap into the knowledge base and experience of skilled practitioners, old-timers and others with valuable craft skills. This provides a helpful foundation for the machine's operating conditions, critical inspection points, reliability history and known failure modes. It also establishes buy-in or ownership among operators, mechanics, technicians and other stakeholders who will be asked to execute and respond to the plan.

Further, a well-constructed inspection plan communicates the seriousness of effort and purpose. It documents

that Inspection 2.0 differentiates considerably from the conventional inspection practices of the past. These differences are necessary to achieve the optimised level of machine reliability established by the asset owner. All forward progress depends on change.

When writing your inspection plan, consider the topics outlined below:

MULTIPLE DISCIPLINES

For many (but not all) organisations, inspections should be cross-disciplinary. They should include lubrication, mechanical maintenance, electrical, safety and operational inspections. It makes little sense to conduct one survey for lubrication, followed by a similar survey for electrical systems on the same machine. If your plant has different maintenance planners for different maintenance functions (mechanical, electrical, production, etc.), inspections can easily be divided once the information has been gathered. The critical path is getting good data and all the data. The rest will fall in place accordingly.

RANKED FAILURE MODES

What are the questions that inspections are supposed to answer? There could be many, but one is always your machine's general state of health. Specifically, is there confirmation of health or evidence of incipient or impending failure conditions. Therefore, we need to know the types of failures we should look for, ranked by likelihood and risk factor. Further, we need to know the specific inspection tasks and methods that can alert us to a failure in progress and how advanced it might be.

Next, we need to understand the root causes associated with each of these ranked failure modes and how inspection might recognise these root causes. One root cause can be associated with multiple failure modes. It's important to catch root causes early enough to prevent the onset of failure. We also care about knowing that all known high-risk failure modes have at least one or more methods (detectors) in our inspection plan that can reliably reveal their early presence.

MACHINE INSPECTION OWNERSHIP: OPERATOR OR RESIDENT EXPERT

Each inspection task or method, defined by the inspection plan, must be performed with seriousness of purpose. The inspector should be responsible and accountable for quality work. In some organisations, the machine operator is the best choice for such an inspector. This person works physically close to the machines and can recognise subtle differences between normal and abnormal. This is often referred to as operator-driven inspection.

In other cases, the inspector may be an inspection technician who works full-time in many or all disciplines of condition monitoring, including inspection. Or perhaps the inspector is the resident expert who only does certain critical inspection routes. The advantage here is the more rigorous training and continuous practice. Combining deep inspection knowledge with a linguistic understanding of other condition monitoring technologies (e.g., oil analysis, vibration, thermography, etc.) can result in enormous value and effectiveness.



Large planetary gearbox

INSPECTION POINTS

Inspection points are physical locations on the machine that must be defined clearly in the inspection plan. These could be couplings, shaft/seal interfaces, breathers, hose connections, sight glasses, gauges, reservoirs, etc. Some inspection points are not visible. For instance, consider the inspection task of touching the upper inside wall of the gear case through the fill port with your fingers. The inspection is looking for moisture condensation and soft deposits. This inspection point is not visible but is necessary to assess certain headspace and lubricant conditions. Another example might be using a probe or dipstick to reach into the machine to collect inspection data.

INSPECTION TASKS AND METHODS

Knowing where to inspect is the start. Next, you must perform the inspection (or make the observation) as designated by the inspection plan. This can be extremely simple (e.g., determine the oil level from the sight glass) or a bit more complex (e.g., use a laser point to determine the abnormal presence of hard or soft particle contamination). The inspection plan must reference a procedure if the task or method involves many steps or requires special techniques or tools. The procedure is a documented



Sight glass

PLANNING AND STRATEGY

method of performing certain inspections and includes the steps, the tools and the means of data collection.

INSPECTOR SKILLS, TRAINING AND QUALIFICATION

Inspection 2.0 requires qualified inspectors with the skills to perform the inspection plan's tasks and methods. The more complex the inspection method or task, the more there is a need for a detailed inspection procedure and training by the inspector on that procedure. An inspector must qualify to perform inspections.

This means we can't assign inspection assignments to anybody regardless of education, work experience or responsibility. Engineers with advanced degrees don't have the skills to meet the inspection tasks defined by Inspection 2.0 based only on the engineering curriculum.

TOOLS NEEDED

Inspection must be enabled to achieve condition monitoring quality and effectiveness to its full potential. This is the essence of Inspection 2.0. As mentioned, this increasingly means modifying and accessorising machines to inspect better and to reach new inspection points. Additionally, inspectors, like any professional or tradesperson, need a toolbox to function fully in their craft.

Many tools or inspection aids enable inspections that otherwise could not be performed. In other cases, they might reduce the time needed to complete an inspection and/or they could enhance the quality and effectiveness of the inspection. The inspection plan (or the referenced procedure) should list the tools needed. Don't cripple inspection performance by pretending to save money by scrimping on inspection tools and aids.

INSPECTION FINDINGS AND DATA COLLECTION

The type of inspection data to be collected and how it will be reported need to be included in the inspection plan. This can reduce the variability that could occur, for instance, by two inspectors doing the same inspections on the same inspection point using the same methods and inspection aids. It is best if data collection is uniform and has structure.



Stroboscope gearbox inspection



Revealed bearing damage from a teardown inspection

This is the concept behind using a structured form or checklist on a handheld data collector or manual paper-based data collection. Inspection is data acquisition that is meaningful, quality and timely. This data doesn't stand alone but needs to be an integral part of the overall condition monitoring scheme.

Handheld electronic data collectors can show images and comparators to help more precisely score an inspection result or finding. Rather than a binary yes-or-no response, it may be scaled from 1-10. Each possible result on this scale is defined by a range of comparator images or a short narrative using the data collector's software interface. This reduces individual subjectivity and provides a scalable analog-like feature to capture and quantify the degree of changing conditions. It's essential to identify an active change.

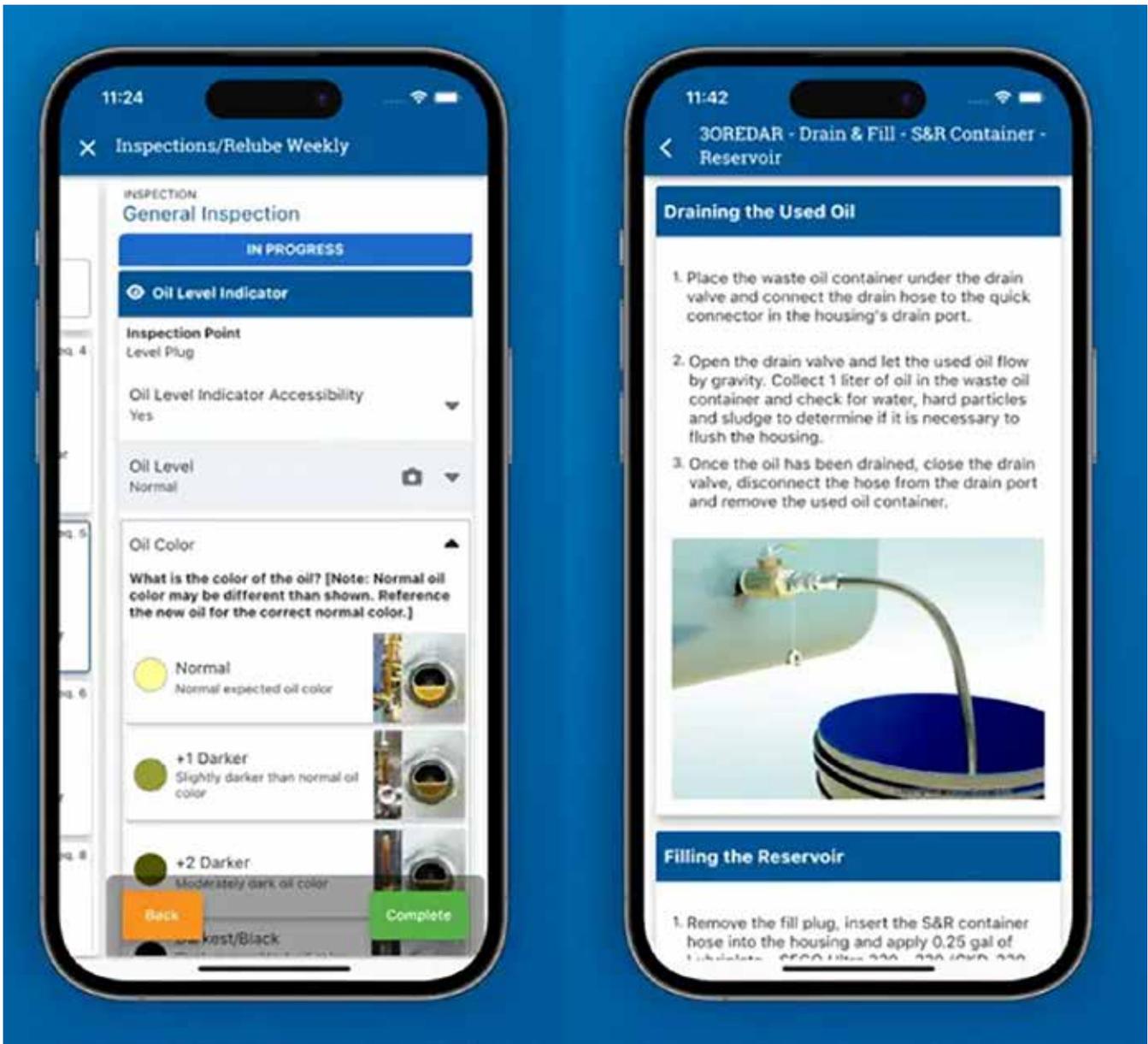
Numerical data collection from inspection routes can be integrated with condition monitoring software to show patterns of changing conditions across an array of data types on the same machine and machine condition.

ROUTE-BASED INSPECTIONS

Many inspection points can be compiled and arranged into a route for a given plant or job site. This is especially helpful when a specialised inspection instrument or tool is used on only a few machines and inspection points. Like many other route-based condition monitoring data collection tasks, its use can be scheduled.

For example, a portable water contamination tester (for lubricants) may only be needed on machines used intermittently and exposed to water sources. In other cases, it might not be a required tool but a particular skill that one inspector might have but others do not. Of course, this skill may be associated with a tool or instruction – a person trained in ultraviolet leak detection. Patch testing and wear debris analysis are other specialised skills.

Most inspections are done daily by the same inspectors or operators assigned to a group of machines. These are sometimes called "walkabout" or "walkaround" inspections. They should in no way be viewed as trivial or unimportant to machine condition monitoring.



LubePM

Additionally, an inspection can be condition-based, triggered by concerning data or observations flagged during a routine inspection, portable data collector or remote condition monitoring data. In such a case, routes are not needed, and the activity is more diagnostic or troubleshooting in nature.

The inspection plan should document the timing and frequency of inspection routes.

METRICS AND COMPLIANCE

All business areas and processes require measurement and reporting. Based on this information, managers can make better, more informed decisions based on an accurate representation of the business and the state of their machines. This is both at a macro level (the forest) and a micro level (the trees). Managers also need lagging indicators (what just happened) and leading indicators (what will happen).

Data for these metrics can come from numerous different condition monitoring sources and then be filtered or streamlined to make them ready for decision-makers use.

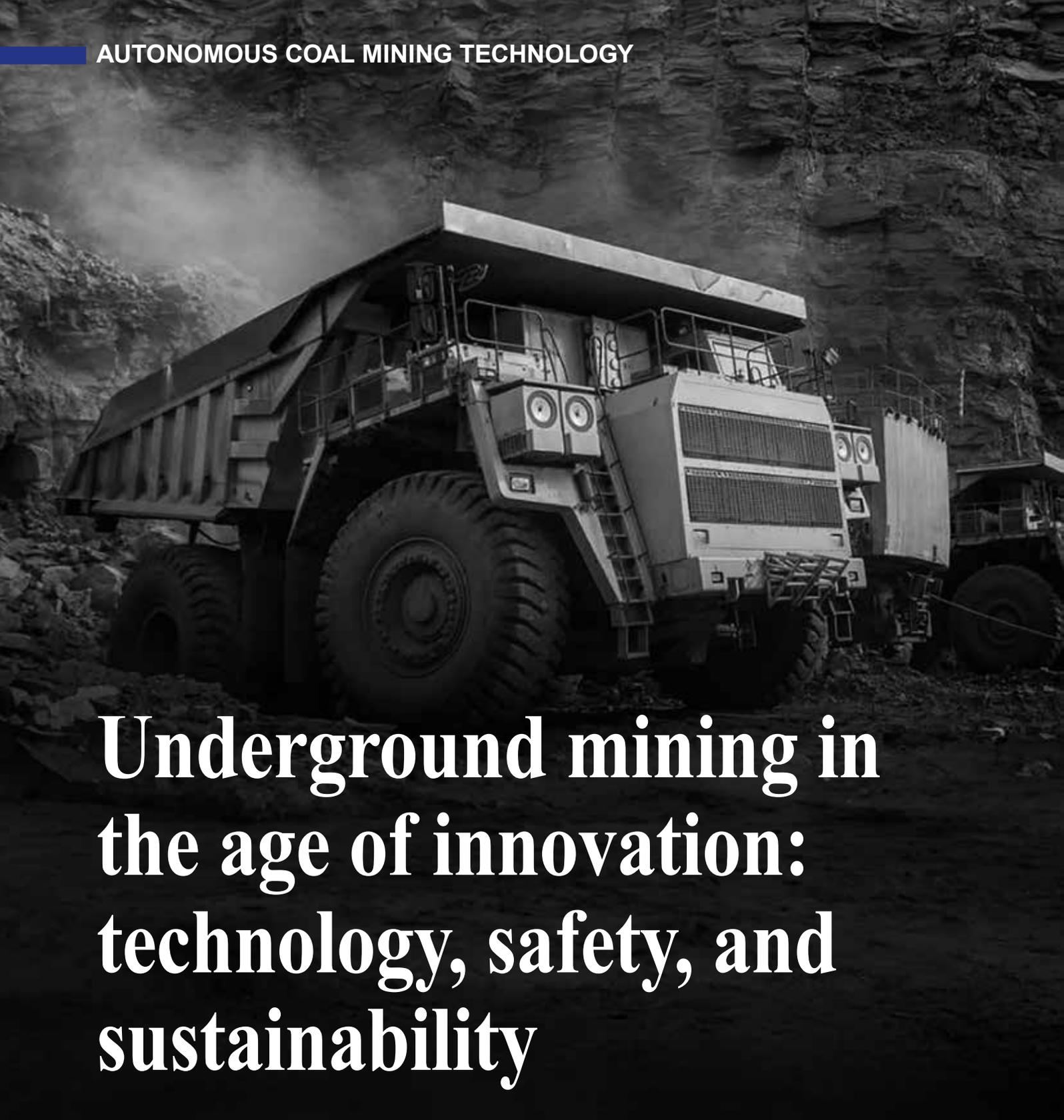
Just like other forms of condition monitoring, inspection is a valuable source of information related to machine reliability and asset management. This is especially true when the data quality is at the level of Inspection 2.0.

Metrics need to also include compliance. Inspections often trigger work orders to remediate current problems found by inspectors. Some work orders involve more probing inspections or troubleshooting tasks. Are these getting done in a timely fashion? Compliance tracking, measurement and reporting may also be needed to verify that all inspection routes are being effectively completed.

AUTHOR

Jim Fitch, a founder and CEO of Noria Corporation, has a wealth of experience in lubrication, oil analysis, and machinery failure investigations. He has advised hundreds of companies on developing their lubrication and oil analysis programs.





Underground mining in the age of innovation: technology, safety, and sustainability

The aim of this article is to explore several aspects of how autonomous mining can be applied to coal mining in order to make operations more efficient and safer with the help of technology. When high-tech robotic / autonomous equipment is deployed, it demonstrates great productivity gains and less human suffering.

The extraction of critical resources – minerals, metals, and hydrocarbons – has underpinned economic development

throughout human history. Today, mining is a \$1 trillion global industry, supplying essential inputs to energy systems, infrastructure, manufacturing, and consumer markets. At the heart of this sector lies a technological transformation: the deployment of advanced systems that enable deeper, safer, and more sustainable underground mining.

Gordon Barratt of Coal International takes a detailed look at how the coal industry utilises the current technology available.

THE FOUR TECHNOLOGICAL REVOLUTIONS IN MINING: FROM MANUAL LABOR TO SMART DIGITAL OPERATIONS

Mining has undergone a series of transformative technological revolutions over the past three centuries, each redefining the way mineral resources are extracted, processed, and transported. These revolutions can be broadly categorised into four distinct phases: manual labour, mechanisation, automation, and digitisation. Each phase has progressively enhanced productivity, safety, and operational efficiency across the global mining sector.

FIRST REVOLUTION: THE MANUAL AND STEAM-POWERED ERA

The first industrial revolution in mining began in the 1700's with the transition from purely manual labour to the use of steam-powered machinery. This period marked the early stages of mechanisation, with innovations such as steam engines and rail transport systems significantly improving ore haulage and material handling. These developments reduced the industry's reliance on human and animal labour, laying the groundwork for more efficient and scalable operations.

SECOND REVOLUTION: ELECTRIFICATION AND MECHANISATION

The second major leap occurred in the 19th and early 20th centuries with the introduction of electricity into mining operations. Electrical pumps were first deployed to dewater coal mines, enabling deeper and more productive extraction. This era also witnessed the widespread adoption of mechanical equipment such as continuous miners, longwall systems, haul trucks, loaders, shuttle cars, and conveyor belts.

By the 1920's, mechanisation had begun to take hold in regions like West Virginia, and by the 1970's, the majority of coal production was mechanised. This shift not only improved productivity but also had a profound impact on mine safety. U.S. fatality statistics illustrate this trend: 883 deaths in 1911 fell to 322 in 1941 and 164 by 1971. Mechanisation removed workers from many of the most hazardous tasks, although human operators were still required to control the equipment, maintaining some level of exposure to risk.

THIRD REVOLUTION: AUTOMATION AND COMPUTERISATION

The third revolution introduced automation into mining operations, targeting repetitive and precision-dependent tasks. Early examples included unmanned rail carriages, remote-controlled ore extraction systems, and automated rock-bolting machines. This phase also marked the beginning of computerisation in mining, with programmable logic controllers (PLCs) being implemented in coal preparation plants to automate start-up and shutdown sequences.

Automation brought several operational advantages: faster task execution, improved precision, and reduced human exposure to hazardous environments. These systems also contributed to more efficient resource utilisation and a lower environmental footprint. Despite these benefits, the adoption of automation has not been as widespread or

uniform as mechanisation. Challenges such as integration complexity, capital investment, and workforce adaptation have slowed its full-scale implementation.

FOURTH REVOLUTION: DIGITISATION AND SMART MINING

The most recent and ongoing transformation is the digitisation of mining. This revolution is characterised by the integration of advanced communication systems, wireless connectivity, and intelligent technologies such as artificial intelligence (AI), machine learning (ML), and large language models (LLMs). These tools are enabling the development of zero-entry mining concepts, where human presence on-site is minimised or eliminated altogether.

Digitisation supports real-time monitoring, predictive maintenance, and data-driven decision-making. As ore grades decline and labour shortages persist, mining companies are increasingly turning to autonomous and remotely operated systems to maintain productivity and improve safety. The integration of remote-control systems with both manned and autonomous equipment has demonstrated measurable improvements in control, accuracy, and operational efficiency.

CONCLUSION

Each technological revolution in mining has built upon the last, driving the industry toward safer, more efficient, and more sustainable operations. While mechanisation and automation have already delivered substantial gains, the current wave of digitisation holds the potential to fundamentally reshape the mining landscape. As the sector continues to evolve, the successful integration of smart technologies will be critical to addressing future challenges and unlocking new opportunities in resource development.

MEETING GLOBAL DEMAND: THE PUSH TOWARD DEPTH

As global population and industrialisation accelerate, so too does the demand for mineral resources. To meet this need, mining operations are extending further underground, accessing deeper ore bodies that require sophisticated planning, engineering, and technology. These environments present significant challenges: elevated geo-stress, rock bursts, gas outbursts, and extreme temperatures all pose risks to personnel and equipment.

Moreover, the disparity in resource consumption between developed and developing nations – where high-income countries consume over six times the resources of low-income ones – has intensified scrutiny on sustainability and long-term resource availability. The industry must now balance economic viability with environmental responsibility and operational safety.

Technological Advancements in Underground Mining

To address these challenges, the mining sector is embracing a suite of emerging technologies across several domains:

AUTOMATION AND REMOTE OPERATIONS

Automation is reshaping underground mining operations. Autonomous drilling rigs, load-haul-dump machines



Use of drones in underground coal mining

(LHDs), and haul trucks are increasingly replacing manual labour, improving safety and productivity. These systems are equipped with:

- Advanced sensors and robotic components
- Semi-autonomous and fully autonomous control
- Proximity detection and fleet tracking

Companies such as Rio Tinto have demonstrated the value of autonomous drilling, where a single operator can manage multiple rigs remotely, reducing exposure and labour costs while enhancing efficiency.

Drones and remote-operated vehicles are also being deployed for inspection, blast planning, and inventory monitoring, enabling data collection from hazardous zones without endangering personnel.

SAFETY TECHNOLOGIES

Safety remains paramount in underground operations. Recent innovations include:

- Smart helmets with integrated environmental and biometric sensors
- Wearable devices for real-time health and stress monitoring
- RFID-based proximity tracking for personnel and equipment
- Augmented and virtual reality tools for training and maintenance
- Gas detection systems to mitigate exposure risks

These technologies enhance situational awareness, enable proactive hazard management, and support emergency response protocols.

ENVIRONMENTAL MANAGEMENT AND SUSTAINABILITY

Mining's environmental footprint is under increasing scrutiny. Key areas of focus include:

- Electrification of fleets and machinery to reduce emissions
- Integration of renewable energy sources



Autonomous dump truck

- Water management strategies to prevent contamination
- Tailings and land rehabilitation practices to restore ecosystems

Organisations such as CSIRO are developing rapid water treatment technologies to ensure compliance with discharge standards and protect local environments.

DIGITISATION AND DATA ANALYTICS

The digital transformation of mining is underway. Industry 4.0 technologies – AI, big data, digital twins, and smart sensors – are enabling:

Predictive maintenance to reduce downtime and extend equipment life.

- Real-time monitoring of operations and environmental conditions
- Enhanced exploration and resource modelling
- Improved decision-making through integrated data platforms

The mine of the future will be a connected, intelligent system capable of autonomous optimisation and adaptive planning.

AUTONOMOUS ROBOTICS IN COAL MINING

Underground coal mining is experiencing a change in basic assumptions with the integration of autonomous robotics. Nearly 50% of underground coal mines now utilise robotic systems such as self-driving haul trucks and remote drills. These technologies offer:

- Reduction in fatality rates (currently 1.37 per 10,000 workers in the U.S.)
- Productivity gains of up to 20%
- Operating cost reductions of approximately 15%

Companies are advancing supervised autonomy frameworks to ensure safe deployment in unpredictable underground environments.



Intelligent connectivity



Remote control mining

STRATEGIC CHALLENGES AND FUTURE DIRECTIONS

Despite the promise of innovation, several barriers remain:

- High capital investment requirements
- Regulatory and compliance complexities
- Workforce training and change management
- Data security and system integration
- Technical limitations in ultra-deep mining

Looking forward, the industry is exploring novel approaches such as fluidised mining – a concept involving unmanned operations, automated sorting, resource fluidisation, backfilling, and intelligent energy control. This may offer solutions to depth limitations and further reduce human exposure.

CONCLUSION

To remain competitive, safe, and sustainable, the mining industry must continue its transition toward advanced technologies. Automation, digitisation, robotics, and environmental stewardship are no longer optional – they are strategic imperatives. While challenges persist, the benefits are clear: improved safety, enhanced productivity, reduced environmental impact, and long-term viability.

Autonomous Haul Trucks

AUTONOMOUS DRONE TECHNOLOGY IN UNDERGROUND MINING: APPLICATIONS, CHALLENGES, AND FUTURE DIRECTIONS

Autonomous drone technology is rapidly emerging as a transformative asset in the mining sector, offering innovative solutions to the complex operational challenges inherent in underground environments.

OPERATIONAL APPLICATIONS AND CAPABILITIES

Autonomous drones are being integrated into underground mining operations to support a range of critical functions, including:

- Real-time mapping and geospatial surveying for tunnel geometry and stope characterisation
- Ventilation and air quality monitoring to assess airflow dynamics and detect hazardous gases
- Rockfall and structural hazard detection using advanced imaging and sensor fusion
- Maintenance and infrastructure inspection, particularly in inaccessible or high-risk zones

These applications are enabled by a suite of sophisticated



AUTONOMOUS COAL MINING TECHNOLOGY

technologies, including high-resolution sensors, advanced inertial navigation systems, and robust wireless communication platforms designed to operate in GPS-denied environments.

Enabling Technologies

Drone performance underground relies on:

- Sensor arrays for environmental monitoring, obstacle avoidance, and structural analysis
- SLAM (Simultaneous Localisation and Mapping) algorithms for autonomous navigation
- Mesh network communication systems for real-time data transmission and fleet coordination
- Edge computing capabilities to process data locally and reduce latency

These systems collectively enhance operational efficiency, reduce human exposure to hazardous conditions, and support data-driven decision-making.

CHALLENGES AND LIMITATIONS

Despite their promise, autonomous drones face several implementation challenges:

- Safety and reliability in confined, dust-laden, and low-light environments
- Regulatory constraints related to autonomous flight in industrial settings
- Technological limitations, including battery life, payload capacity, and signal interference
- Integration complexity with existing mine systems and workflows

Addressing these challenges requires coordinated efforts across engineering, regulatory, and operational domains.

FUTURE DIRECTIONS

Looking ahead, the next phase of drone innovation in mining will be driven by:

- Artificial intelligence (AI) for adaptive flight control, anomaly detection, and predictive analytics
- Enhanced sensor systems for multi-modal data acquisition and improved situational awareness

- Zero-entry mining concepts, where drones and autonomous systems perform all underground tasks without human presence

These advancements will further support the industry's transition toward intelligent, automated, and safer mining operations.

TRANSFORMING COAL MINING OPERATIONS THROUGH AUTOMATED DRILLING AND BLASTING SYSTEMS

The mining industry is undergoing a profound transformation driven by the adoption of automated drilling and blasting systems. These technologies represent a paradigm shift in how underground coal mining operations are executed, combining precise mechanical control with real-time data analytics to deliver safer, more efficient, and more predictable outcomes.

At the heart of these systems is the integration of advanced sensor networks embedded within drilling rigs. These sensors continuously capture critical variables such as vibration, temperature, and pressure. The data is processed through sophisticated analytics platforms capable of making near-instantaneous adjustments to drilling parameters. This closed-loop feedback mechanism ensures that each blast is executed with precision, minimising risk and maximising productivity.

OPERATIONAL BENEFITS AND SAFETY ENHANCEMENTS

Automation in drilling and blasting significantly reduces delays and minimises the need for direct human intervention in hazardous environments. These systems are programmed to adapt dynamically to changing underground conditions, making them indispensable for managing the complex and variable nature of coal mines. Continuous monitoring, combined with Business Intelligence (BI) integration, enables operators to optimise workflows, enhance output, and safeguard the health and safety of the workforce.

The ability to monitor and respond to environmental and operational data in real time also contributes to improved blast outcomes, reduced overbreak, and more efficient fragmentation. These improvements translate into better material handling, reduced secondary breakage, and lower overall operational costs.





IMPLEMENTATION CHALLENGES AND ORGANISATIONAL SHIFTS

Despite the clear advantages, transitioning from manual to automated drilling and blasting systems presents several challenges. The shift requires substantial investment in hardware, software, and workforce training. Moreover, it demands a cultural transformation within mining organisations that have long relied on traditional, time-tested methods.

One of the primary obstacles is the integration of legacy infrastructure with modern automation platforms. Many existing systems are not inherently compatible with contemporary technologies, necessitating phased implementation strategies and careful planning. Additionally, comprehensive training programs are essential to ensure that personnel – particularly those in supervisory and technical roles – can effectively interpret and act upon the data generated by these systems.

Resistance to change is another factor that must be addressed. Successful adoption hinges on clear communication of the benefits, hands-on training, and the demonstration of tangible improvements in safety and productivity.

STRATEGIC ADVANTAGES AND FUTURE OUTLOOK

Forward-looking mining companies are already realising the long-term benefits of automation. Enhanced operational efficiency, improved safety standards, and a stronger competitive position are among the key outcomes. For operations undergoing large-scale digital transformation, features such as Bulk Operations allow for the simultaneous implementation of changes across multiple datasets, ensuring consistency and reducing the learning curve.

Looking ahead, the future of coal mining will be increasingly shaped by artificial intelligence, machine learning, and

sensor-driven automation. These technologies are expected to further refine drilling and blasting processes, enabling systems to operate with minimal human oversight while maintaining high levels of accuracy and responsiveness.

The development of integrated platforms that merge operational data with real-time analytics will drive radical innovation in mine management. Enhanced interoperability between technological components will allow for seamless communication across systems, making each phase of the mining process – from exploration to extraction – more intelligent and predictable.

THE ROLE OF BUSINESS INTELLIGENCE AND DATA ANALYTICS

As mining operations become more data-centric, the strategic use of Business Intelligence and Data Analytics will be critical. Companies that can effectively harness and interpret large datasets will be better equipped to forecast maintenance needs, optimise blast designs, and improve overall productivity. Tools such as the Admin Tools module exemplify how centralised data control can streamline user management, financial transactions, and operational oversight.

In conclusion, automated drilling and blasting systems are redefining coal mining by merging mechanical precision with digital intelligence. While implementation requires thoughtful planning and investment, the long-term gains in safety, efficiency, and strategic agility make automation an essential component of modern mining operations.

DIGITAL GAS MONITORING FOR UNDERGROUND ENVIRONMENTS

Underground coal mining inherently involves the release of hazardous gases, which, if not properly managed, can pose



significant risks to worker safety and operational integrity. Among the most common and dangerous gases encountered in coal mines are methane (CH₄), carbon monoxide (CO), carbon dioxide (CO₂), and hydrogen sulphide (H₂S). Each of these gases presents unique threats, necessitating vigilant monitoring and control measures.

Methane is a highly flammable gas frequently released during coal extraction. It forms explosive mixtures with air at concentrations between 5% and 15%, making it a leading cause of mining-related fatalities. Carbon monoxide, a colourless and odourless gas produced by incomplete combustion, is extremely toxic even at low concentrations. Carbon dioxide, while less hazardous, can displace oxygen and lead to suffocation. Hydrogen sulphide, identifiable by its characteristic odour, is both toxic and potentially fatal at elevated levels.

Given the dangers posed by these gases, robust gas monitoring systems have become a cornerstone of modern mine safety protocols. Historically, gas detection relied on rudimentary methods. The iconic “canary in the coal mine” served as an early warning system; the bird’s distress signalled compromised air quality. Subsequent developments introduced handheld gas detectors, which, while useful, lacked the capacity for continuous, real-time monitoring across extensive underground networks.

The advent of digital technologies and automation has revolutionised gas monitoring in mining. Contemporary systems are designed to provide continuous surveillance, real-time data analysis, and immediate alerts, thereby significantly reducing the risk of explosions, fires, and toxic exposure. These systems comprise several integrated

components that collectively enhance safety and operational efficiency.

FIXED AND PORTABLE DETECTION SYSTEMS

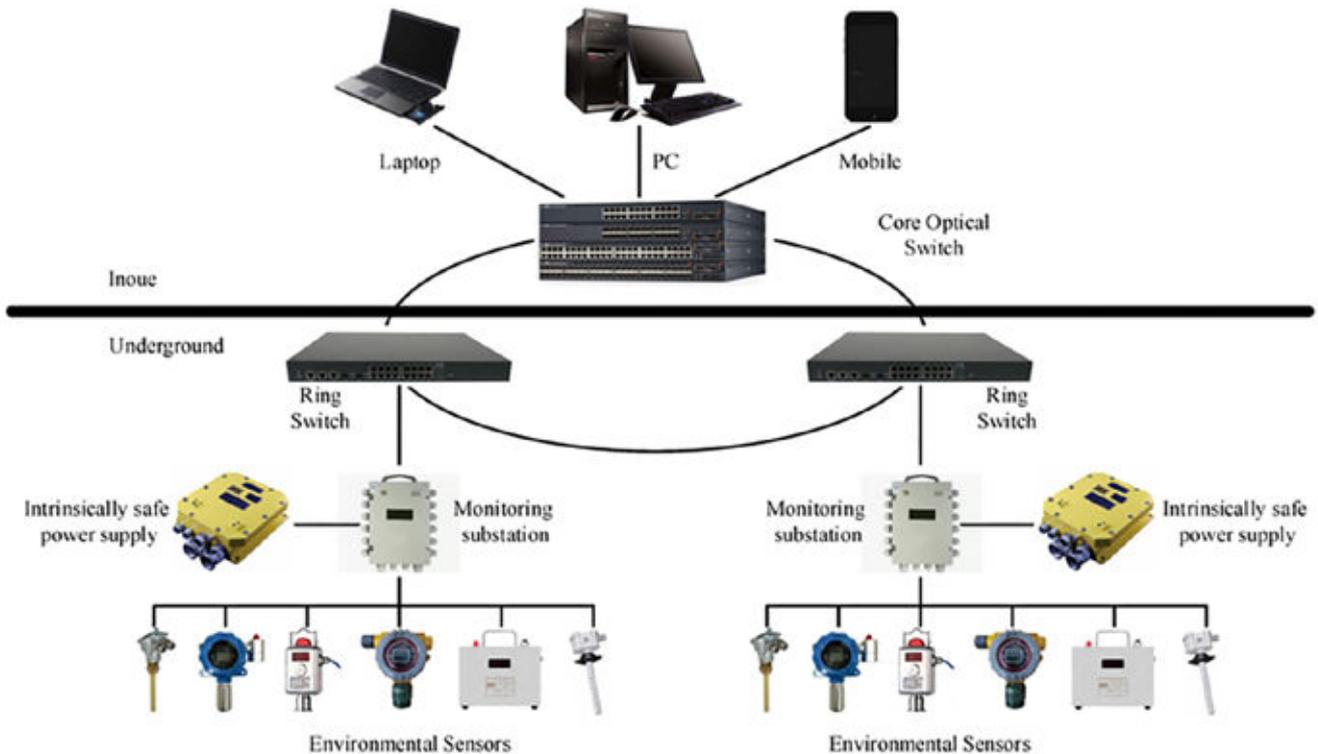
Fixed gas sensors are strategically installed throughout the mine, particularly in areas susceptible to gas accumulation such as coal seams, ventilation shafts, and working faces. These sensors offer precise measurements of gas concentrations and are often tailored to detect specific gases. Methane detectors, for instance, are calibrated to identify explosive thresholds, while multi-gas detectors can simultaneously monitor methane, carbon monoxide, carbon dioxide, and hydrogen sulphide.

Complementing fixed systems are portable gas detectors carried by individual miners. These devices provide immediate readings of ambient gas levels and are equipped with customisable alerts to warn users when concentrations approach critical thresholds. This dual-layered approach ensures both localised and network-wide monitoring.

CENTRALISED MONITORING AND AUTOMATED VENTILATION

Data collected from fixed and portable detectors is transmitted to centralised monitoring stations, where it is analysed in real time. These systems employ advanced algorithms to identify trends, anomalies, and potential hazards. When gas levels exceed safe limits, automated alerts are dispatched to both underground personnel and surface operators.

Modern monitoring systems are often integrated with automated ventilation controls. In response to elevated gas concentrations, these systems dynamically adjust airflow to



Framework of underground coal mine environmental monitoring system

dilute and expel hazardous gases. Fail-safe mechanisms, including backup fans and auxiliary ventilation units, ensure uninterrupted airflow even in the event of primary system failure.

WIRELESS COMMUNICATION AND SYSTEM INTEGRATION

Wireless communication networks have further enhanced the responsiveness of gas monitoring systems. These networks facilitate instantaneous data exchange between sensors, detectors, and control rooms, enabling swift dissemination of safety alerts and operational updates. Mine-wide connectivity ensures that all stakeholders are informed simultaneously, allowing for rapid intervention or evacuation when necessary.

SAFETY BENEFITS AND REGULATORY COMPLIANCE

The implementation of modern gas monitoring systems yields several critical safety benefits. Foremost among these is the early detection of methane buildups, which allows operators to take pre-emptive measures before explosive conditions arise. Continuous monitoring and real-time alerts minimise the lag between gas accumulation and operator response, thereby averting potential disasters.

Ventilation management is also markedly improved. Automated systems respond dynamically to changing gas levels, ensuring that hazardous concentrations are promptly diluted and removed. This not only prevents explosions but also mitigates long-term health risks associated with exposure to toxic gases such as carbon monoxide and hydrogen sulphide.

Furthermore, these systems support compliance with stringent safety regulations. Regulatory agencies mandate

detailed documentation of gas levels, incidents, and mitigation efforts. Modern monitoring technologies facilitate this by automatically generating comprehensive data logs, streamlining reporting and audit processes.

Mine rescue robots

DEPLOYMENT OF ROBOTIC SYSTEMS IN POST-DISASTER MINE RESCUE OPERATIONS

The initial hours following a mine disaster are critical in determining the survivability of personnel trapped underground. Rapid deployment of autonomous or remotely operated robotic platforms – equipped with gas detection instrumentation and low-light imaging systems – can play a decisive role in early-stage reconnaissance and hazard assessment.

Underground environments are inherently challenging, characterised by confined geometries, elevated temperatures, high humidity, poor visibility, and atmospheres often laden with toxic or explosive gases. Post-incident conditions exacerbate these hazards, impeding human access and delaying rescue efforts. Dense concentrations of dust and smoke frequently obscure visibility, halting progress and consuming valuable time during the most vital rescue window.

In coal mining operations, the risk profile intensifies due to the presence of methane, coal dust, and firedamp, all of which pose significant explosion hazards. Secondary ignition events remain a persistent threat, further complicating rescue logistics. In such scenarios, mobile subterranean robots offer a robust solution. These units can be deployed immediately, irrespective of atmospheric

conditions, and are capable of performing 3D spatial mapping to retrieve critical data from inaccessible zones.

Rescue robots are engineered to navigate compromised mine workings, identify viable egress routes for trapped personnel, and evaluate the structural and atmospheric integrity of the environment prior to human entry. Localisation remains a key technical challenge in these operations.

ROBOTIC PLATFORMS IN MINE RESCUE

Originally developed by Remotec for military bomb disposal applications, the Wolverine robot was adapted for mining use in 2001. Operated via a fibre optic tether with a reach of up to 1,524 meters, the unit is equipped with three onboard cameras delivering real-time visual feedback, and a gas sensor for continuous atmospheric sampling. These features enable remote navigation and hazard assessment, minimising risk to rescue personnel.

Despite its capabilities, the Wolverine robot has demonstrated limitations in operational contexts. Its substantial weight and dependence on tethered communication have restricted manoeuvrability and deployment flexibility in certain mine emergencies. While the robot has been utilised in actual rescue scenarios, performance constraints have led to incomplete mission outcomes. Remotec continues to refine the design to address these operational shortcomings.

Developed by Sandia National Laboratories and commercialised by Black-I Robotics, the Gemini Scout is a purpose-built coal mine rescue robot. It transmits wireless telemetry including continuous gas monitoring data, high-resolution colour imagery, and stereo depth information. The platform integrates a thermal imaging system for survivor detection and a pan-tilt camera for obstacle identification.

Engineered for rugged terrain, the Gemini Scout features rubberised tracks and an articulated chassis, enabling traversal over debris and uneven surfaces. Its lightweight,

intrinsically safe design allows operation in volatile mine atmospheres. Remote control is facilitated through a user-friendly interface modelled on an Xbox 360 controller, streamlining operator training and deployment.

Although the Gemini Scout has not yet been deployed in a live rescue operation, its technical specifications and safety profile position it as a promising asset for future mine emergency response.

Smart helmets

ADVANCING MINER SAFETY THROUGH SMART WEARABLE TECHNOLOGY: THE SUSTAINABLE SMART SAFETY HELMET

Ensuring the safety and health of coal miners remains a paramount concern in underground mining operations, where environmental hazards and physiological stressors pose persistent risks. In response to these challenges a Sustainable Smart Safety Helmet for Coal Miners introduces a novel wearable technology designed to enhance real-time monitoring and hazard response capabilities in coal mining environments.

At the core of this innovation is a microcontroller, a compact and energy-efficient processing unit that serves as the central hub for data acquisition and analysis. The helmet integrates a suite of sensors tailored to monitor both environmental and physiological parameters critical to miner safety. These include:

- **Sensors:** Measuring ambient temperature and humidity, enabling assessment of thermal conditions that may affect miner comfort and health.
- **Gas Sensor:** Detecting harmful gases such as carbon monoxide and other volatile compounds, providing early warning of toxic exposure.
- **Infrared (IR) Sensor:** Monitors helmet usage status, ensuring that the safety system is active only when the helmet is properly worn.
- **Heartbeat Sensor:** Tracks the miner's pulse rate in real time, offering insights into physical stress or potential medical emergencies.



Wolverine Robot



Gemini Scout



Smart Helmet with environmental Sensors for Miners in Coal Mining

To facilitate immediate hazard recognition, the system incorporates an audible output that activates when sensor readings exceed predefined safety thresholds. This direct alert mechanism ensures that miners are promptly informed of dangerous conditions without reliance on external communication.

Data collected by the sensors is continuously processed within the processing microcontroller and transmitted to a mobile application developed using a compatible platform (App). This app provides a user-friendly interface through which miners and supervisory personnel can access real-time information regarding environmental conditions and individual health metrics. In the event of a detected hazard, the system simultaneously triggers the audible alarm and sends push notifications to the mobile application, enabling swift intervention and decision-making.

The integration of advanced sensor technology, real-time data analytics, and automated alert systems represents a significant advancement in personal protective equipment (PPE) for the mining sector. By delivering continuous situational awareness and empowering miners with actionable safety intelligence, the smart helmet fosters a safer and more responsive working environment.

Moreover, the system's modular design and reliance on low-power components support sustainability objectives, offering a scalable and cost-effective solution for widespread deployment in coal mining operations. As

the industry continues to embrace digital transformation and intelligent safety systems, innovations such as the Sustainable Smart Safety Helmet exemplify the potential of wearable technology to redefine occupational health standards and reinforce miner confidence in high-risk environments.

World's largest fleet of autonomous mining trucks goes live at Chinese coal mine

AUTONOMOUS ELECTRIC HAULAGE AT SCALE: ENGINEERING INSIGHTS FROM CHINA'S YIMIN OPEN-PIT COAL MINE

The Yimin open-pit coal mine in Inner Mongolia has become a global benchmark for large-scale autonomous haulage following the deployment of 100 fully electric, cab-less mining trucks. This initiative, led by the Huaneng Group in collaboration with Huawei, Xuzhou Construction Machinery Group, the Beijing University of Science and Technology, and State Grid Smart Internet of Vehicles Co. Ltd., represents the largest single deployment of autonomous electric mining trucks worldwide.

ENGINEERING A STRATEGIC LEAP IN SMART MINING

The fleet – designated “Huaneng Ruichi” – is powered by Huawei's Commercial Vehicle Autonomous Driving Cloud Service (CVADCS), integrating artificial intelligence, 5G-Advanced (5G-A), and cloud computing to deliver real-time fleet coordination and adaptive route optimisation. According to Huaneng Mengdong chairman Li Shuxue, the project exemplifies China's strategic push to digitise



Mining dump trucks loaded in a coal mine.

traditional industries and modernise coal production through intelligent automation.

PERFORMANCE AND ENVIRONMENTAL DESIGN CONSIDERATIONS

Each autonomous truck is engineered to haul up to 90 tonnes and operate reliably in extreme climatic conditions, including ambient temperatures as low as -40°C. Operational data indicates that the autonomous fleet achieves 120% of the productivity of conventional manned trucks, with a 20% improvement in overall transport efficiency.

These gains are attributed to:

- High-precision digital mapping and navigation systems
- Cloud-based dispatching and coordination platforms
- Automated battery swapping infrastructure, minimising downtime, and supporting continuous operation

CAB-LESS ARCHITECTURE AND SAFETY INTEGRATION

A defining feature of the Huaneng Ruichi fleet is its cabless design – China's first such deployment in mining. By eliminating the operator cabin, the system removes personnel from high-risk zones, significantly enhancing site safety. The CVADCS platform enables:

- Real-time vehicle tracking and diagnostics
- Dynamic route recalibration based on environmental and operational variables
- Reduced idle time through predictive analytics and crowdsourced mapping

5G-ADVANCED CONNECTIVITY FOR REAL-TIME OPERATIONS

The deployment of a 5G-A network at the Yimin site

provides the digital backbone for autonomous operations. With uplink speeds of up to 500 Mbps and latency as low as 20 milliseconds, the network supports:

- Continuous 24/7 fleet operation
- High-definition video surveillance
- Real-time dispatching and remote diagnostics

Huawei's AI algorithms further enhance situational awareness, enabling seamless integration of autonomous systems into daily mine operations.

SUSTAINABILITY AND ENVIRONMENTAL COMPLIANCE

The transition to electric haulage aligns with China's national zero-carbon mining strategy. Located in an ecologically sensitive region bordered by wetlands and grasslands, the Yimin mine benefits from reduced greenhouse gas emissions and minimised environmental disturbance. The project demonstrates how electrification and automation can coexist with environmental stewardship and regulatory compliance.

SCALING AND GLOBAL OUTLOOK

The Yimin deployment is a cornerstone of China's broader automation roadmap. The China National Coal Association forecasts over 5,000 autonomous mining trucks in operation nationwide by the end of 2025, with that number expected to double by 2026. At Yimin, expansion plans are underway to scale the autonomous fleet to 300 units within three years. Huawei and its partners are also evaluating international deployment opportunities, with pilot projects under consideration in Africa and Latin America.



From Maintenance Mode to Market Necessity

F

or more than a decade, the U.S. coal industry has been in decline – with waning investment, shrinking capacity, and the steady rise of gas and renewables. Yet, in 2025, a different story is emerging. Across the country, coal units once scheduled for quiet retirement are being called back into

service in ways few anticipated – driven not by nostalgia, but by a new kind of demand shock: the rise of artificial intelligence (AI), data centres, and industrial reshoring.

Massive, round-the-clock power needs from AI and cloud computing, along with “Made in America” manufacturing growth, have led to a capacity crunch that renewables and gas alone cannot satisfy. Momentarily eased policy pressures have allowed coal plants a second act – one defined not by expansion, but on efficiency, reliability, and return on investment.

FROM SURVIVAL TO SELECTIVE MODERNISATION

Over the past decade, most coal plants operated in “maintenance-only mode.” With low wholesale prices and high regulatory uncertainty, investment was deferred, units slipped to lower efficiency levels, and chronic slagging and fouling became routine.

Now, utilities are being asked to do more, operate more efficiently, and run cleaner without significant capital upgrades. This has pushed operators to focus on selective modernisation, especially in areas that provide immediate, measurable benefits.

RECLAIMING LOST MEGAWATTS THROUGH CHEMISTRY

One of the most effective tools transforming coal economics is fuel chemistry optimisation – led by Environmental Energy Services (EES) and its Coal Treat. Coal Treat additives are applied to the fuel and can alter coal ash characteristics during and after combustion, raising fusion temperatures, decreasing fouling, and recovering lost megawatts.

In one 750-MW tangential-fired boiler, Coal Treat eliminated reheat-section slagging that had previously caused derates. The unit increased output by 3% and lowered NOx emissions by 0.02 lb/MMBtu.

Another 650-MW plant firing high-slag Illinois Basin and Northern Appalachian blends operated five consecutive days at full load – a feat once impossible – after treatment. Infrared boiler cameras confirmed clean pendant and nose-arch surfaces throughout the run.

The economic benefits are equally significant. Switching from premium Central Appalachian to Illinois Basin fuel saved plants \$40 per ton while keeping output and compliance intact. At another location, slagging had lowered furnace exit-gas temperatures by 100F, which improved heat rate by 2.5% and increased net annual revenue by an estimated \$2.5 million.

INSIDE THE PROCESS: HOW ADDITIVES TRANSFORM ASH

Slag formation begins when minerals in coal, such as silicates, iron, sodium, and potassium, are volatilised and/or react during combustion to create high-strength, low-melting point, sometimes glassy deposits that adhere to tube surfaces.



Figure 1: Baseline high-temperature probe (HTP) testing in a Powder River Basin (PRB)-fired 640-MW opposed-wall furnace illustrates how CoalTreat reduces boiler tube slagging. The untreated fuel produced a thick layer of black amorphous glass that accumulated on the HTP (top). The test was repeated one day later with CoalTreat applied to the fuel. Notably, the slag coating on the HTP was more porous, friable, and weakened such that it broke off as the HTP was removed (bottom), confirming the change in ash crystal structure. Courtesy: EES

Coal Treat works by introducing specially formulated chemical additives that alter ash chemistry, promoting the formation of brittle crystals (high-melting crystalline structures like anorthite and hematite) instead of “sticky” amorphous glass. The result:

- Fluxing or molten deposits become solid and friable and are easily removed by soot blowing.
- Ash fusion temperatures increase by 150F to 200F.
- Accumulated slag or fouling is weaker, as shown in sintering strength data, becoming increasingly friable and more easily removed by existing equipment.
- Forced outages and heat transfer losses decrease.

Changes in ash chemistry can be observed through high-temperature probe (HTP) testing that simulates tube-surface conditions (**Figure 1**). Probe accumulations and associated temperature mapping data consistently show reduced slag adhesion and no or reduced “black glass”

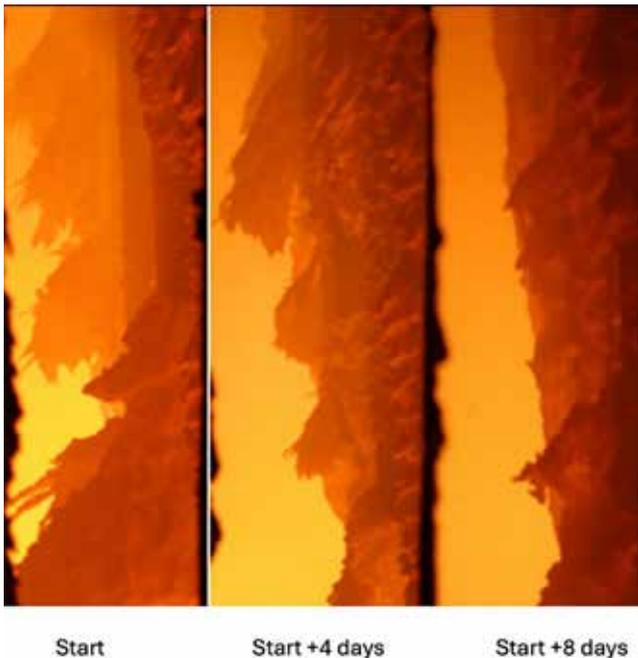


Figure 2: Progression of pendant slagging under baseline conditions and after four and eight days of treatment. The reductions in slag accumulation are clearly present, highlighting the effectiveness of the additive treatment. Courtesy: EES

formation, validating the chemistry’s effectiveness in actual furnace operating conditions (**Figure 2**). HTP testing, along with furnace infrared photography/thermography conducted during field trials can be used to verify performance in short demonstration programs.

FIELD PROVEN: RESTORING LOST MEGAWATTS THROUGH FUEL CHEMISTRY

The shift from maintaining the status quo to a renewed focus on maximising generating capacity and reliability is borne out daily across the U.S. fleet. Utilities that once viewed additive chemistry as a tool of last resort are now actualising significant operational and financial returns. The following case study from a U.S. coal-fired generating unit demonstrates how a targeted CoalTreat program restored lost megawatts, improved heat rate, and delivered multimillion-dollar gains – all without capital upgrades.

CASE STUDY: RESTORING LOST CAPACITY THROUGH CHEMISTRY

A Midwestern public utility operates a 500-MW-class generating unit burning a high-moisture, moderate-ash coal blend. The unit had faced persistent derates and forced outages due to severe slagging. Traditional soot blowing, load-shedding, and best practices proved inadequate, resulting in the loss of thousands of megawatt-hours of generation annually – often during high-value peak periods.

Implementing a custom additive treatment increased ash fusion temperatures by approximately 200F and through crystal changes in the slag reduced adhesion and accumulation. During the initial test period, the plant avoided more than 9,000 MWh of derate due to fouling and cut forced outages by about 120 hours. Additionally, the unit improved its average heat rate by nearly 200 Btu/kWh and significantly lowered boiler maintenance and soot blower steam consumption.

The savings from heat-rate improvement contribute approximately \$1.0 million annually to the plant’s bottom

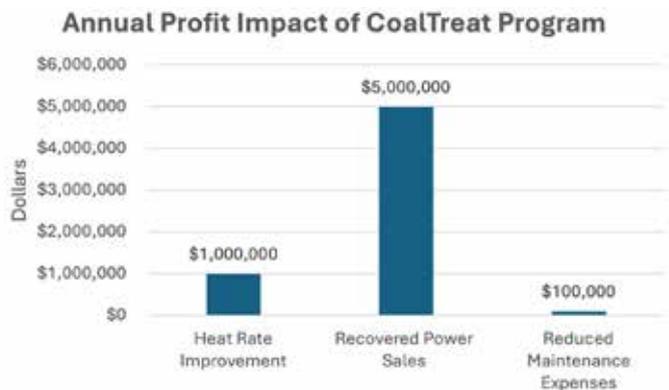


Figure 3: Case study findings emphasise a key point: coal units can regain lost MW and boost profitability through targeted, data-driven fuel chemistry rather than costly retrofits. As shown, optimised combustion and slag-mitigation chemistry delivered several million dollars in annual net profit, driven by improved heat rate, increased power sales, and reduced maintenance costs. Courtesy: ESS



CoalTreat + 1 day



CoalTreat + 8 days

Figure 4: CoalTreat's impact on furnace slagging can be seen as waterwall and pendant slag shedding is observed within the first day of treatment. After a week of continuous treatment, the finer, friable consistency of treated bottom ash is observed. Courtesy: EES

line. Recovered power sales generated a net income of about \$5 million per year (after fuel costs), based on an average power sale price of \$100/MWh. Maintenance savings from reduced boiler cleaning and weld repairs eliminated roughly \$100,000 in annual maintenance expenses.

Peak power sales in many regions will continue to rise. For example, PJM peak power prices hit \$898/MWh on April 8, 2025, and \$1,334/MWh on June 23, 2025. Plants that can increase power sales during peak hours can substantially boost their profitability. For example, at PJM's June 2025 peak (\$1,334/MWh), recovered MWh could yield greater than \$5 million in a single event.

The primary benefit was not just financial. By stabilising combustion and extending tube life, the additive program also lowered safety risks related to explosive cleaning. Moreover, CoalTreat does not require installing water cannons or other costly maintenance additions. CoalTreat has demonstrated increased plant reliability and that chemistry-based performance recovery can replace substantial capital investments and prevent power sales losses during long upgrade outages.

FUEL FLEXIBILITY: THE COMPETITIVE EDGE

With tailored fuel treatment programs, utilities can confidently burn lower-cost, higher-slugging coals without sacrificing performance. This capability to switch between fuel sources offers a valuable hedge against volatile supply and pricing while providing a strategic advantage as dispatch needs evolve with AI-driven baseload growth. By

enabling the use of lower-cost “opportunity” coals without sacrificing performance, plants can realise a significant increase in gross profit and maintain operational flexibility in a shifting energy landscape.

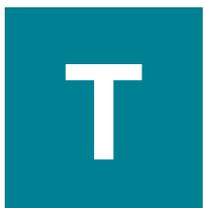
EES's latest CoalTreat On-Demand Systems (ODS) are portable, intelligent treatment systems available for rapid deployment. Reagent dosages and blends are tailored to varying coal types and are capable of automatic control. ODS systems can be used for continuous applications to control persistent slagging or intermittent applications where particular coal blends/seams or operating conditions cause periodic issues.

As AI and reshoring drive unprecedented electricity demand (the U.S. Energy Information Administration predicts 20 GW to 30 GW of new data center load by 2030 – equivalent to more than 50 coal units at 80% capacity factor), the existing coal fleet remains essential for system stability. For utility stakeholders, the message is practical: Invest selectively, measure diligently, and optimise the assets you already have. Every avoided derate, every efficiency improvement, and every ton of fuel flexibility counts in this high-demand environment (**Figure 3**).

In the age of AI and “big data,” coal is not finished yet. By embracing targeted innovation and smarter fuel chemistry, operators demonstrate that legacy assets can adapt (**Figure 4**), delivering cleaner, more reliable, and cost-effective power when the grid needs it most.

P. Robert Santangeli, PE

Who holds the purse strings? Understanding mining procurement power



revor Barratt MD of both Coal International and Mining and Quarry World having worked in the mines during the sixties and Eighties looks at the comparisons as to how the purchase of equipment and services was and to what the requirements are today.

In the early sixties and onwards to today, most Electrical and Mechanical Engineers seldom ventured underground as most problems and every day production would be in the hands of trusted Deputy and Assistant engineers plus shift charge engineers.

The surface officers that the engineers were allocated were used to entertain a plethora of equipment and service company reps trying to convince the engineers to purchase their wares or indeed trial them out. Some became long term suppliers over many years as a result of the friendly and trusted relationship with the engineers. Personal relationships certainly drove deals.

In the world of mining today, where a single equipment decision can sway millions in output and safety, the question is not just what to sell—it is who to speak to.

THE DECISION-MAKERS BEHIND THE MACHINES

Procurement in mining is no longer a back-office function. It is a strategic nerve centre led by:

- **Chief Procurement Officers (CPOs):**
The architects of acquisition strategy. They balance cost, compliance, and innovation across global operations.
- **Category Managers:**

Specialists who know their terrain—whether it is haulage, ground control, or PPE. They are the ones comparing specs, vetting suppliers, and watching market trends.

- **Technical and Operations Teams:**
The boots-on-the-ground voices. Their feedback shapes the shortlist, especially when equipment must match ore characteristics or site conditions.
- **Finance and Legal:**
Guardians of budget and compliance. They scrutinise contracts, assess total cost of ownership, and ensure ESG alignment.

WHAT SWAYS THEIR DECISIONS?

Performance over promises:
Suppliers must show—not just tell—how their equipment performs under real conditions.

Legacy and reliability:
A proven record of accomplishment still matters. Editorial storytelling can elevate a supplier’s reputation beyond the spec sheet.

Support and service:
Procurement teams value long-term partnerships. Training, uptime guarantees, and responsive service tip the scales.

Mining companies prioritise cost-efficiency, ore characteristics, production scale, and regulatory compliance when selecting equipment and services. Strategic decisions are shaped by both technical performance and long-term sustainability.

Here is a detailed breakdown of the key factors that

influence mining companies in their selection process:

Ore Characteristics and Processing Needs

- Physical and chemical properties of the ore—such as hardness, grain size, and mineral composition—dictate the type of equipment needed.
- For example, abrasive ores require robust crushers and mills, while softer ores may be processed with lighter machinery.
- The mineralogical makeup also determines the separation techniques (e.g., flotation, gravity, magnetic), each requiring specific equipment.

Production Scale and Throughput

- Large-scale operations demand high-capacity equipment to handle vast volumes efficiently.
- Smaller or modular operations benefit from flexible, scalable machinery that can adapt to changing production needs.
- Cost and Operational Efficiency
- Loading and hauling equipment often represent over half of total mining costs, making their selection critical.
- Companies assess initial investment, fuel consumption, maintenance costs, and expected lifespan.
- Decision-support systems are increasingly used to evaluate complex criteria and optimise cost-performance balance.

Integration and Compatibility

- Equipment must integrate seamlessly with existing systems, from fleet logistics to automation platforms.
- Compatibility with crew scheduling, maintenance routines, and site layout is essential for smooth operations.

Environmental and Regulatory Compliance

- Modern equipment often includes emission controls, noise reduction, and energy-efficient designs to meet environmental standards.
- Compliance with local and international safety regulations is non-negotiable, influencing both equipment choice and service providers.

Vendor Reputation and Support Services

- Mining firms value reliable after-sales service, training, and technical support.
- Long-term partnerships with trusted suppliers who offer consistent quality and innovation can sway decisions.

Strategic and Legacy Considerations

- Some companies factor in historical performance, brand loyalty, and legacy integration—especially in operations with deep-rooted supplier relationships.

The author shows the comparisons between the 1960's and Eighties.

INFOGRAPHIC CONCEPT: WHAT SWAYS MINING COMPANIES? THEN AND NOW.

1. Technical Fit

Then (1960's-80's):

- Manual compatibility with crew skills
- Ruggedness over precision
- Brand loyalty to legacy suppliers

Now:

- Ore-specific performance (abrasion, throughput, recovery)
- Automation-ready systems
- Modular and scalable designs

2. Cost-Efficiency

Then:

- Lowest upfront cost wins
- Repairs handled in-house.
- Fuel and wear accepted as sunk cost.

Now:

- Total cost of ownership (TCO) analysis
- Predictive maintenance and uptime guarantee
- Fuel efficiency and carbon offset potential.

3. Strategic Integration

Then:

- Equipment chosen in isolation.
- Service contracts as afterthought.

Now:

- Full ecosystem planning (haulage, processing, safety)
- Supplier partnerships with training, data, and support
- Decision-support software guiding selection.

4. Regulatory & Environmental Compliance

Then:

- Minimal oversight
- Local standards only

Now:

- Global ESG benchmarks
- Emission controls, noise reduction, dust suppression
- Equipment tied to sustainability reporting

5. Supplier Reputation & Legacy

Then:

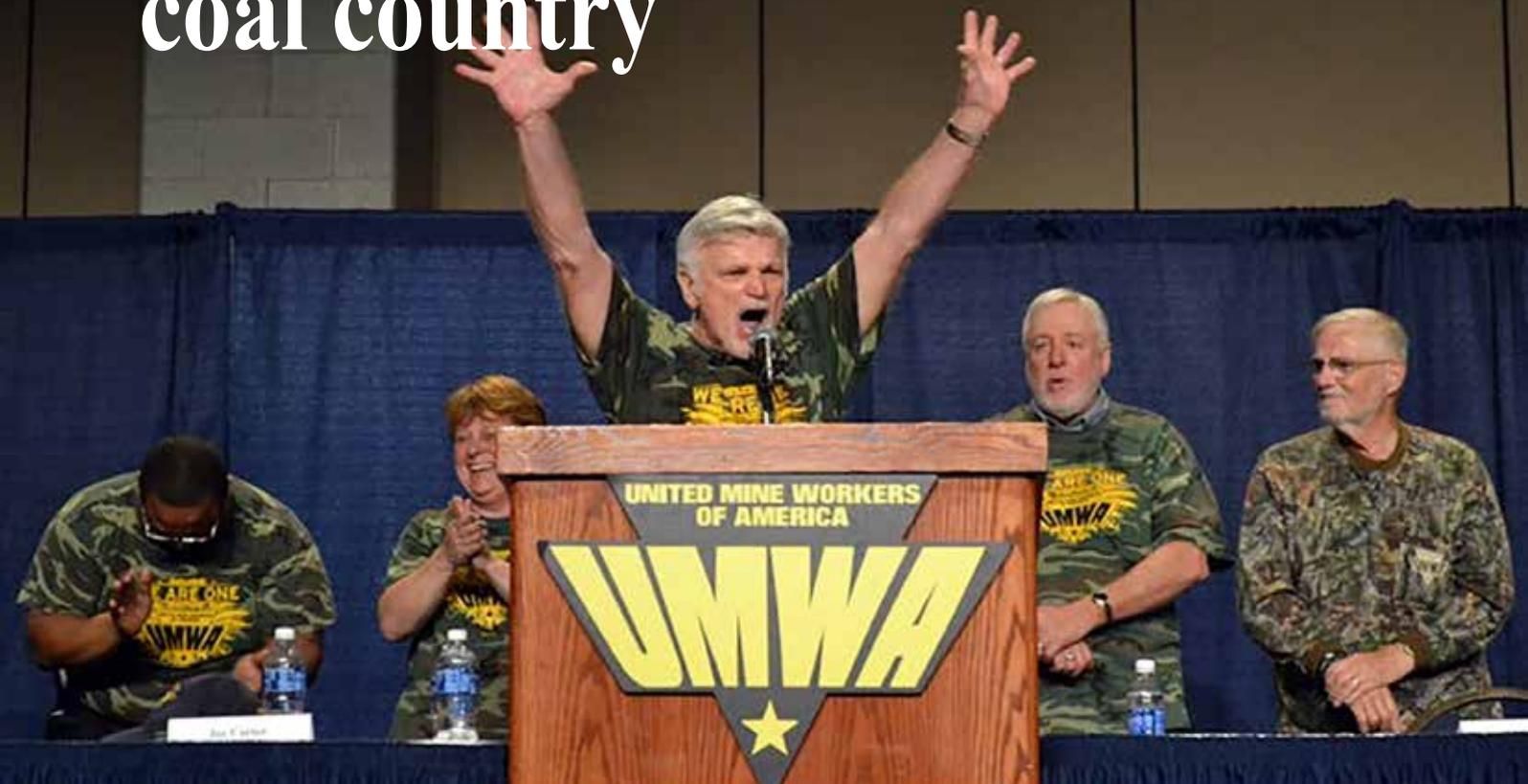
- "We've always used them."

Personal relationships drive deals.

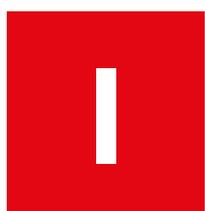
Now:

- Proven innovation and reliability
- Transparent service metrics

From the pulpit to the picket line: For many miners, religion and labour rights have long been connected in coal country



United Mine Workers of America President Cecil Roberts speaks to about 4,000 retired members in Lexington, Kentucky, on June 14, 2016.



In October 2025, Cecil Roberts retired from his role as president of the United Mine Workers of America. A sixth-generation coal miner, he has led the union for 30 years. Only one man held the role longer: John L. Lewis, whom many consider one of the most important labour leaders of

the 20th century.

Roberts has seen the union through an especially difficult period for the coal industry and grew up immersed in it. He was raised in Cabin Creek, West Virginia, where his

great-grandmother – an activist in her own right – let miners camp on her property during a legendary strike in 1912. Bill Blizzard, his great-uncle, led miners during the Battle of Blair Mountain, the largest labour uprising in U.S. history. Both of his grandfathers died in mine accidents.

And there's another way Roberts is steeped in Appalachian history: Before an audience of workers, observers have often noted, he speaks like a preacher. Roberts likens miners' struggles to biblical stories, references the power of God and the teachings of Jesus, and speaks in the dynamic cadences found in an Appalachian church.

“Be like Jesus,” he told a rally in Charleston, West Virginia, in 2015, opposing a “right to work” bill that allowed workers in union-run shops to opt out of paying dues. “Jesus saw the money changers in the temple, and Jesus drove the money changers from the temple. So let me tell the National Right to Work Committee, the Chamber of Commerce, the Koch Brothers, and all those who gave money: you got your money’s worth, but we are not for sale in West Virginia.”

“How many of you have been to a Baptist church? We are going to take up a collection. It is altar call time,” he continued. “Now, I am going to ask you something: Are you fed up? Let me hear you say, ‘Fed up.’... Are you so fed up that you are now fired up? Let me hear you say, ‘Fired up!’”

Capping off the rousing call-and-response, he shouted, “God bless all of you, you’re the salt of the earth!”

DISINFORMATION IS DANGEROUS. WE FIGHT IT WITH FACTS AND EXPERTISE.

About us

Roberts’ style is a glimpse into a bigger story. For over a century, coal has transformed central Appalachia: from the

shape of the landscape to place names, and from folk music and crafts to economic conditions. All the while, religion has been transforming in the mountains, too. Labour and religion are deeply entangled here – a subject I explored in my book “Work and Faith in the Kentucky Coal Fields: Subject to Dust.”

‘RAILROAD RELIGION’

In the 1880’s, two groups rushed into the central Appalachian Mountains: industrialists seeking coal, and missionaries seeking moral reform. Both changed the region forever, and their stories were intertwined.

At the time, central Appalachia was widely depicted in the popular press as a backward, ignorant region whose mountainous terrain kept its people isolated, outside the flow of progress – a stereotype still common today. Equating economic progress with moral progress, many Americans assumed that developing industry would lift people out of what they perceived as fatalism and superstition.

The coal industry used this idea to promote its rapid exploitation of mountain resources. Companies built railroads to connect the region to the national market,



Henry Ford founded Twin Branch, W.Va. – shown here in the 1920s – as a town for coal miners.

developed industrial coal mines and reshaped the central Appalachian economy. Missionaries opened churches, schools and camps.

Company-owned coal towns encompassed miners' lives. People who had long farmed for themselves and lived, as the Bible told them to, "by the sweat of their brow," became dependent upon coal companies as mine development shrank the size of family farms. Not only did employers own the miners' houses, but they also paid workers in "scrip," which was redeemable only at the company store.

Many company towns included theatre's, offered films and music, and even built churches and paid pastors' salaries. These were typically mainline Protestant churches, such as Methodist or Presbyterian.

To some Appalachian natives, these denominations were known as "railroad religion" because of the way they

entered the mountains. And, for many miners, these were the churches of management. When there was labour unrest, the coal town churches tended to side with the companies, advising miners against strikes or agitation.

FAITH AND ACTION

The churches of most miners born in central Appalachia, meanwhile, were in the mountain communities – independent Baptist or Holiness congregations whose pastors were usually miners themselves.

Pastors preached about the dangers and sacrifices miners faced deep underground, in an age of few regulations. God was on the side of the oppressed and downtrodden, they stressed – and those who gained at others' expense would ultimately face divine judgment.

Their passionate preaching was meant to inspire action, whether it was committing one's life to Jesus or to



A Primitive Baptist church congregation – a denomination also known as Old School Baptists – witnesses a baptism in Triplett Creek, Ky., in 1940.



Miners in Harlan County, Ky., arrive at the Pentecostal Church of God building for a union meeting in 1946. Department of the Interior/National Archives at College Park via Wikimedia Commons



A memorial in Whitesville, W.Va., honours the 29 miners killed in a 2010 explosion in Massey Energy's Upper Big Branch coal mine in nearby Montcoal.



the union. Labor rights were deeply understood as religious issues, rooted in Christian concerns for justice and care.

John Sayles' 1987 film "Matewan" powerfully depicted the divided role that religion played in West Virginia's coalfields. One preacher, played by Sayles, equates the union with "the Prince of Darkness." Another, a young miner, advocates in biblical terms for the union's righteousness and helps to lead a strike. The result was the Matewan Massacre of 1920: a bloody battle between miners and armed guards hired by the mine owners.

Miner preachers and independent churches were central to the organisation of miners in eastern Kentucky in the 1930s, too, during another period of violence between mine operators and miners over conditions, wages and unionisation. It was during this time that miner's wife and singer Sarah Ogan Gunning penned "Dreadful Memories," turning the traditional hymn "Precious Memories" into a visceral depiction of miners' struggle and a call for unionisation:

*"Dreadful memories, how they linger,
How they ever flood my soul.
How the workers and their children
Died from hunger and from cold."*

LOOKING TO THE FUTURE

Today, it is still not surprising to find religious – particularly Christian – rhetoric in labour organising. United Auto Workers President Shawn Fain is another example of a union leader whose speeches draw from the Bible.

But the dynamics of religion and class forged by industrial mining have shaped central Appalachia's culture in lasting ways particular to the coalfields. The history of labour struggle, infused with religious idioms, is a source of identity and values evident in everything from union meetings in churches to prayers on picket lines.

Today, the United Mine Workers of America is focused less on coal itself, which miners know cannot last forever. The union represents members in other sectors, too, including public employees, manufacturing, health care and employees of the Navajo Nation. It has also focused its work on an equitable transition to renewable energy: one that accounts for the economic, cultural and environmental destruction that a single-industry economy has wreaked on central Appalachia.

Likewise, the United Mine Workers of America has fought to hold coal companies to their pension and health care obligations toward retired and sick miners whose work fuelled the country and made companies rich.

And that struggle, Roberts would say, is a religious one as well.

PIT-FOLK AND PEERS

Now, in his retirement, he has published the second volume of a detailed history of his place of birth – the former pit village of Fryston, near Castleford, West Yorkshire.

"It's my sense of responsibility and privilege to tell the story on behalf of the people of Fryston, Castleford, and the Yorkshire coalfield," he says. "There's a heritage there that belongs to the nation, as well as the people of Fryston."

The recently released Pit-folk and Peers Volume 2: Diamonds and Rust (1909-2023) is described as a chronicle of Fryston's mining heritage and its remarkable people. The first volume, Echoes of Fryston Hall (1809-1908) was released during the Covid pandemic in 2020 and explored a rich, aristocratic history of the area in the 19th century.

The second volume continues to follow that family line as it intersects with the major political developments of the 20th century and also follows the fortunes of the pit-folk of what was once a quintessential coal mining village.

"If you look at the importance of mining for the industrial revolution and beyond, coal mining has been a staple source of fuelling British industry, wealth and power," says David. "We are a nation, an island, built on coal."

His ancestors were at the heart of the industry boom, his father, uncles, grandad, and other relatives all working in the coalfields. He recalls, during his adolescence in the early 1970s, a sort of political awakening.

"Miners were starting to become more assertive," he remembers. "Arthur Scargill was coming on the scene. We were beginning to ask questions and take a bit more pride in ourselves."

In the run up to beginning a psychology degree at university in York, David remembers watching Ken Loach's TV serialisation Days of Hope.

The drama followed the lives of a working-class family, from the First World War to the General Strike in 1926 – the walkout of thousands of workers, which began in solidarity with miners involved in industrial dispute.

"I thought these are my folks here, this is my grandad and grandma," David, 68, says. "And I started to develop an appreciation for what they'd done, what they'd gone through, the obstacles they'd overturned."

He soon became fascinated by this heritage and spent around 30 years at what is now Sheffield Hallam University researching and writing on the sociology of mining communities.

In the 1980s, that work took him to picket lines and demonstrations during industrial action and has since seen him explore relations in the British coal industry and the policing of protests, as well as the regeneration of former coal mining areas.

"You're socialised a certain way in mining towns like Castleford and villages like Fryston," says David, who now lives in Sheffield. "There's a mutuality there...And it was beginning to shape my identity."



For years, he says he has felt an “emotional obligation” to highlight his hometown and its connections to the coalfields. “I always knew sooner or later, probably in retirement, that I would do these books,” he says. “This is me having an emotional connection but at the same time having tools at my disposal, a long experience of doing research in this area.”

Volume 1 of his two-part history focuses primarily on the cultural, political, and philanthropic figure of Richard Monckton Milnes (the first Lord Houghton), and emphasises the significance of his Fryston Hall estate as a major hub of Victorian society. It also traces the emergence of Fryston Colliery, following its sinking in 1873, and the creation of a small, adjoining village for mineworkers and their families.

This volume switches attention onto the important political, ambassadorial, and literary activities of Houghton’s son Lord Crewe. It also documents the continuing fortunes and accomplishments of the local mine and its associated community.

In the 1940s and 50s, for example, the colliery pioneered a charitable scheme providing motorised vehicles for paraplegic miners; local mineworkers built with their own hands a welfare hall and a village sports stadium; and

a Fryston pit deputy was awarded the George Medal for staging a daring underground rescue.

David’s book examines such activities but also documents the often arduous, everyday reality of mining families, as well as the miners’ strike of 1984-85 and the village’s “near extinction” following the closure of Fryston Colliery in 1985.

There is also a chapter on efforts to revitalise the area, including redevelopments that featured on Channel 4 as part of a regeneration programme called The Castleford Project.

Reflecting on the volumes, David says: “My academic career has concentrated primarily on aspects of mining and the industry – the struggles, the strikes and also the nature of community, the demise of community and the regeneration of it.

“In many ways, these books on Fryston are the final pages, the culmination of a personal and academic journey over many years.”

Pit-folk and Peers: The Remarkable History of the People of Fryston: Volume 2: Diamonds and Rust (1909-2023) by David Waddington, published by Route, is out now.

Coal International

Proposed subjects for Coal International

Every issue of **Coal International** contains the latest news, new plant and equipment, health, safety and sustainability and digitisation issues affecting the industry. Site visits plus a one on one interview with top executives and engineers within the industry. All year round focused articles from exploration through to production. A major feature throughout each issue will be: Reducing your carbon footprint, Sustainability and Mining Innovation.



January

Feature: "Beyond Bolting: The Next Frontier in Roof Support"

- Machine monitoring The IoT
- Carbon capture and storage
- Shearers
- Ventilation systems
- Conveying underground
- Dust suppression

Case Studies: Mine water heat networks in former coalfields

Deadline date for all materials: 18/01/2026

Copy Date: 31/01/2026

March

Feature: Automation, AI, and unmanned mining systems

- Underground mining trucks
- Gas monitoring
- Shearers
- Sustainable mining practices
- Conveying: Belt technology
- Online training solutions

Deadline date for all materials: 22/03/2026

Copy Date: 31/03/2026

May

Feature: Global regulatory shifts and ESG alignment

- Machine monitoring The IoT
- Transitioning mines to sustainable future
- Dewatering pumps
- Health and Safety innovations
- Machine monitoring The IoT
- Conveying Technology...Scrapers and Cleaners
- Longwall systems
- Conveying Technology

Case Studies: Auxiliary Fleet Utilisation

Deadline date for all materials: 17/05/2026

Copy Date: 31/05/2026

July

Feature: Critical minerals and decarbonization pathway

- Hybrid mining machines
- Underground shuttle cars
- Autonomous mining
- Underground/Surface conveyor dust suppression
- Carbon capture and storage
- Shearers

Deadline date for all materials: 19/07/2026

Copy Date: 31/07/2026

September

Feature: Supplier profiles and market access strategies

- Pumps and water management
- Rock reinforcement and ground support
- Wheel loaders
- Transitioning to an electric mine
- Conveying
- AFC Stage loader review

Case Studies: Coal Mine Innovation

Deadline date for all materials: 20/09/2026

Copy Date: 30/09/2026

November

Feature: Clean coal technologies and energy transition strategies

- Open Pit mining
- Conveying Technology
- Crushing and Screening
- Explosives technology
- Lubrication
- Sustainable mining practices

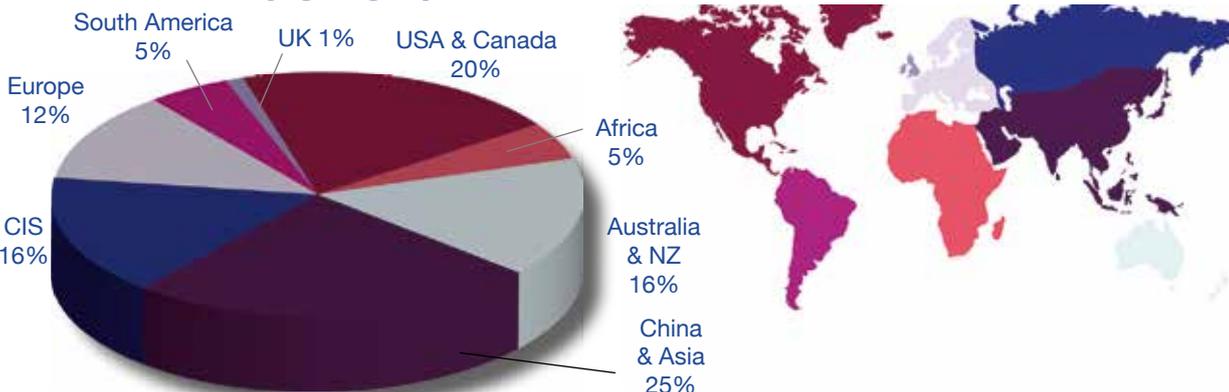
Deadline date for all materials: 15/11/2026

Copy Date: 30/01/2026

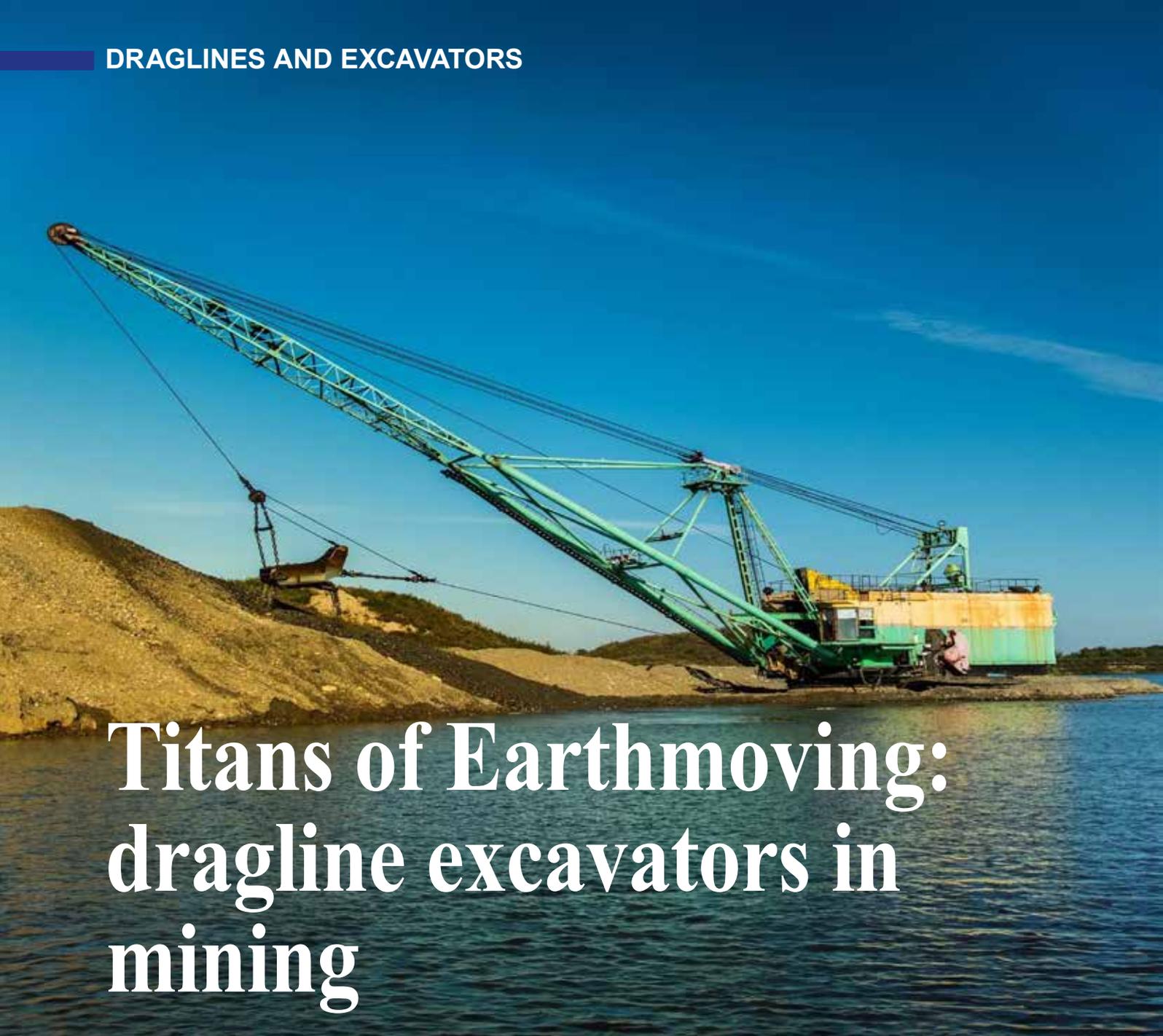
Further articles of interest will be added throughout the year, if you would like to forward articles for consideration please contact gordon.barratt@tradelinkpub.com

Coal International will be attending major exhibitions around the world (as listed on page 4) ensuring your message reaches its intended audience. Prior to attendance at exhibitions we will ensure that a digital copy reaches all Operating Companies/ Mining Operations personnel, this will include Head Office: CEO's, Technical Directors, Procurement Departments and CFO's Mine site: Mine Manager, Electrical/ Mechanical Engineers and Health/Safety officers. Printed Bonus copies will also be available for distribution from the event attendance.

Circulation by geographical area



To advertise in *Coal International*, contact gordon.barratt@tradelinkpub.com | Tel +44 (0)1777 871007 / +44 (0)7506 053527



Titans of Earthmoving: dragline excavators in mining

Dragline excavators are among the most colossal and powerful machines ever built for surface mining. These mechanical giants have revolutionised the way we extract resources from the Earth, combining brute strength with engineering finesse to move unimaginable volumes of material. Spanning over a century, Dragline excavators have played a pivotal role in shaping modern mining and construction. Their journey through the years is marked by engineering breakthroughs, industrial demands, and ever-growing ambitions to move more earth, faster. *Gordon Barratt of Coal International takes a detailed look at these giants of industry.*



RIGINS: EARLY 20TH CENTURY INNOVATION

Modern dragline excavators rank among the most formidable machines in the mining industry. Their construction demands advanced engineering expertise, while their operation necessitates substantial logistical support, including significant resource allocation and skilled manpower.

Invented in 1904 by John W. Page, the dragline excavator was designed as a more efficient alternative to steam shovels. The invention of the dragline in 1904 was a significant advancement in earthmoving machinery. The dragline was designed to dig the Chicago Canal and was later adapted for use in various construction and mining projects. Page's innovation laid the foundation for the dragline's evolution and continued use in the construction and mining industries.

- Initially used in civil engineering, these early machines were cable-operated and mounted on rail tracks or wheeled platforms.
- Their ability to reach further and dig deeper made them ideal for canal dredging and foundation work.

Rise of the Giants: 1920s-1950s

- As mining operations expanded, so did the size and capability of draglines.
- The 1920s saw the introduction of walking mechanisms, allowing draglines to reposition themselves without external transport.
- By the 1950s, draglines had become essential in strip mining, especially for coal, where they removed overburden with unmatched efficiency.

This era marked the construction of the largest draglines ever built:

BAGGER 288 (GERMANY)

The Bagger 288 is a monumental bucketwheel excavator recognised as the largest terrestrial machine ever constructed. Commissioned in 1978, it measures 315 feet in height, extends 721 feet in length, and weighs approximately 45,500 tons. Engineered for high-capacity operations, it is capable of excavating up to 240,000 tons of material per day.

BIG MUSKIE (UNITED STATES)

Situated in Ohio, Big Muskie held the title of the world's largest dragline excavator from its commissioning in 1969 until its decommissioning in 1991. Matching Bagger 288 in height at 315 feet, it weighed 13,500 tons and featured one of the largest buckets ever manufactured. Its daily excavation capacity reached 240,000 tons.

MARINA BARRAGE (SINGAPORE)

Constructed in 2006, the Marina Barrage is the largest dipper dragline excavator globally. Located in Singapore, it stands 270 feet tall and is capable of excavating up to 150,000 tons of material per day. Its scale and performance place it among the most advanced dragline systems in operation.

MARRONG (AUSTRALIA)

The Marrong dragline excavator, built in 2001 and located in Australia, is currently the largest of its kind. Towering at 330 feet, it boasts a digging depth of up to 250 feet and a radius exceeding 1,000 feet. With a daily capacity of 120,000 tons, Marrong exemplifies the pinnacle of dragline engineering.

These four machines exemplify the extraordinary scale and technological sophistication achieved in modern dragline excavator design. Their operation demands extensive resources, specialised engineering, and coordinated manpower, underscoring their status as some of the most formidable industrial machines in existence.

Below highlights a few technical details of the largest dragline ever built.

Big Muskie was the largest dragline excavator ever built, a monumental feat of engineering that operated in Ohio from 1969 to 1991. It stood 222 feet tall, weighed 13,500 tons, and could move 325 tons of earth in a single scoop.

CONSTRUCTION AND DESIGN

- Manufacturer: Bucyrus-Erie, model 4250-W – the only one of its kind ever built.
- Construction Time: Over 200,000 man-hours across two years.
- Cost: \$25 million in 1969 (equivalent to over \$214 million today).
- Dimensions:
 - Height: 222 feet (67.6 m) – nearly 22 stories tall.
 - Length: 487 feet (148.6 m) with boom lowered.
 - Boom Length: 310 feet (94.5 m).
 - Width: 151 feet (46.2 m) – comparable to an eight-lane highway.

Technical Specifications

- Weight: 13,500 short tons (12,247 metric tons).
 - Bucket Capacity: 220-325 cubic yards (holds two Greyhound buses side-by-side).
 - Power Supply: 13,800 volts via trailing cable.
 - Installed Power: 18.04 MW (24,192 hp) from 18 x 1,000 hp drives and 10 x 625 hp DC motors.
 - Mobility: Hydraulically driven walker feet; top speed of 0.1 mph.
- ### Operation and Legacy
- Operator: Central Ohio Coal Company (a division of American Electric Power).
 - Crew: Required a team of 30-40 technicians working in rotating shifts.
 - Hourly Operating Cost: Estimated at \$2,500.
 - Function: Designed for high-volume strip mining, capable of removing vast layers of overburden to expose coal seams.

Service Life: Active from 1969 to 1991, scrapped in 1999.

HISTORICAL SIGNIFICANCE

Big Muskie was not only the largest dragline excavator but also one of the most powerful mobile earth-moving machines ever constructed. It reshaped the landscape



of southeastern Ohio and became a symbol of industrial might. Though dismantled, its bucket remains on display as a monument to mining history.

- These machines were assembled onsite due to their size and operated for decades in massive open-pit mines.
- Electric motors replaced diesel engines, improving power and reducing emissions.

Modern draglines incorporate digital AC drive systems, precision controls, and real-time diagnostics.

- The P&H 9020XPC, introduced in the 2010s, features boom lengths up to 425 feet and bucket capacities of 160 cubic yards.
- Automation and machine learning are now optimising performance, reducing downtime, and enhancing safety.



Draglines have shaped landscapes across the globe – from coal fields in the U.S. to oil sands in Canada and mineral mines in Australia.

- Though rotary excavators and other technologies have challenged their dominance, draglines remain unmatched in certain high-volume earthmoving tasks.

A dragline excavator is a type of heavy equipment used primarily in surface mining and civil engineering. It consists of a large bucket suspended from a boom by wire ropes. The bucket is manoeuvred using a combination of hoist and drag ropes, allowing it to scoop up material and swing it to a designated dumping area.

Unlike conventional excavators, draglines operate with a unique method: the bucket is cast out and dragged back toward the machine, scraping up earth as it moves. This technique enables them to excavate large areas quickly and efficiently.

Dragline excavators are indispensable in strip mining operations, especially for coal and oil sands. Their primary role is to remove overburden – the layers of soil and rock that lie above valuable mineral seams. Once the overburden is cleared, miners can access and extract the underlying resources.

Key advantages in mining include:

- High productivity: Capable of moving hundreds of tons per pass.
- Long reach: Ideal for deep pits and wide benches.
- Longevity: Machines can operate for decades with proper maintenance.

Draglines fall into two main categories:

1. Standard Lift Crane-Type
 - Built offsite and transported to the mining location.
 - Smaller and more mobile.
 - Commonly used in civil engineering projects like road construction and dredging.
2. Onsite-Constructed Giants
 - Assembled directly at the mining site due to their massive size.
 - Immobile and designed for long-term use.
 - Used in large-scale strip mining operations.



Size and Capacity

Feature	Earlier Models (e.g., Big Muskie)	Modern Models (e.g., P&H 9020XPC)
Boom Length	~310 ft	Up to 425 ft
Bucket Capacity	~220-325 tons	110-160 cubic yards
Operating Weight	~13,500 tons	~7,500-8,000 tons

A typical dragline excavator includes:

- Boom: A long truss-like arm that supports the bucket.
- Bucket: The massive scoop used for excavation.
- Hoist Rope: Raises and lowers the bucket.
- Drag Rope: Pulls the bucket horizontally.
- Swing Mechanism: Rotates the boom to dump material.

Some of the largest draglines, like Big Muskie and the P&H 9020XPC, have booms over 300 feet long and buckets that can carry up to 325 tons of material.

ENVIRONMENTAL AND OPERATIONAL CONSIDERATIONS

While draglines are efficient, they require careful planning:

- Site preparation: Due to their size, draglines need stable ground and ample space.
- Energy consumption: They are powered by massive diesel or electric motors.
- Environmental impact: Responsible mining practices are essential to mitigate land disruption.

HOW DO MODERN DRAGLINES COMPARE TO EARLIER MODELS?

Modern dragline excavators represent a significant leap forward in engineering, efficiency, and environmental responsibility compared to their earlier counterparts. Here's a breakdown of how they compare:

Modern draglines are slightly lighter but maintain comparable or greater reach and capacity thanks to improved materials and design.

Power and Efficiency

- Earlier models relied on massive diesel or basic electric motors, with limited control over energy use.
- Modern draglines use digital AC drive systems, which offer:
 - Precise control over hoist and drag operations
 - Reduced energy consumption
 - Lower maintenance costs

Automation and Control

- Legacy machines were manually operated with

analogue controls.

- Today's draglines feature:
 - Real-time diagnostics
 - Automated cycle optimisation
 - Remote monitoring and predictive maintenance

These upgrades improve uptime and reduce human error.

Environmental Impact

- Older draglines were energy-intensive and lacked emissions controls.
- Modern machines are designed with sustainability in mind:
 - Electric drives reduce carbon footprint
 - Advanced systems minimise ground disturbance
 - Better dust and noise suppression technologies

Maintenance and Reliability

- Earlier models like the Marion 7400 were praised for simplicity but required frequent manual upkeep.
- Modern draglines balance complexity with reliability, using modular components and smart systems to reduce downtime.

SUMMARY

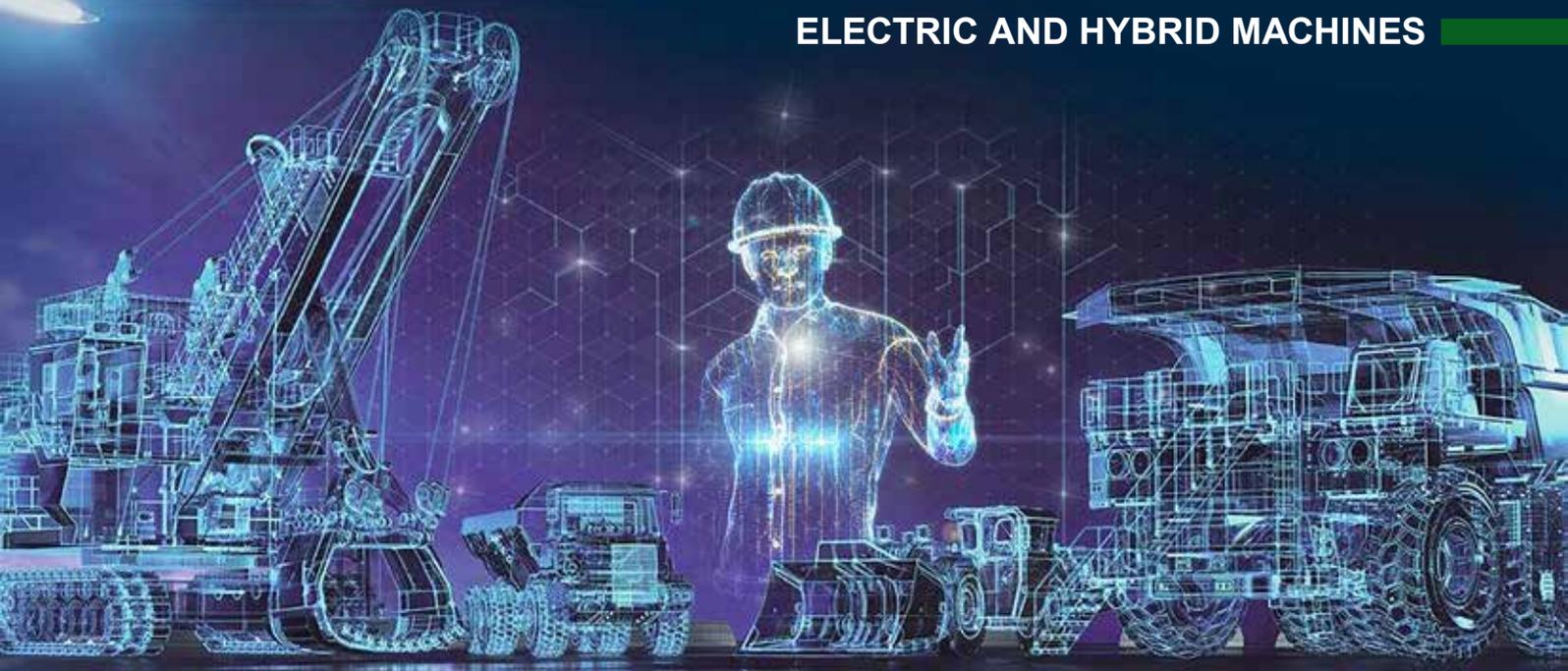
Modern draglines are smarter, more efficient, and environmentally conscious while still delivering the brute strength needed for large-scale mining. They reflect a shift from raw mechanical power to intelligent, optimised performance.

Would you like a visual comparison or a timeline of dragline evolution next?

CONCLUSION

Dragline excavators are the titans of surface mining – machines that embody the scale and ambition of modern resource extraction. Their ability to move mountains (literally) makes them vital to industries that rely on large-scale earthmoving, from coal mining to civil infrastructure.

From cable-operated pioneers to digital giants, dragline excavators embody the evolution of industrial ambition. Their history is not just about machines – it's a story of human ingenuity, resource extraction, and the relentless drive to dig deeper.



Electric and Hybrid Machines: changing the way we mine

Electric and hybrid mining machines are reshaping the industry by cutting fuel use, improving working conditions, and boosting performance. Instead of relying solely on diesel fleets, battery-electric and hybrid equipment slash emissions, clean up underground air, and reduce the need for heavy ventilation systems. That means healthier crews and lower operating costs.

T

hese machines aren't just cleaner – they're powerful. Electric drivetrains deliver instant torque, giving strong pull-on steep ramps and often matching or beating diesel productivity. With advances in battery packs, trolley-assist systems, and

fast or swappable charging setups, uptime stays high and operations run smoothly.

Battery and hybrid mining machines are now firmly established as transitional technologies: hybrids are proving reliable in large-scale haulage, while battery-electric equipment is gaining traction underground, driven by stricter emission rules and advances in lithium-ion technology.

Gordon Barratt of Coal International evaluates the roles of Hybrid and Battery-Electric machines within the mining industry.



WHAT'S IN THE FLEET?

The current mining fleet integrates a range of advanced equipment designed to balance productivity with sustainability. Haul trucks powered by battery, trolley, and hybrid systems are engineered to handle heavy loads while reducing fuel consumption. Excavators, loaders, and drills are configured to minimise noise and emissions without compromising output, ensuring that production levels remain consistently high. Complementing these machines are digital monitoring systems that track performance, anticipate maintenance requirements, and reduce downtime, thereby maximising equipment availability and operational efficiency. For underground crews, electrification delivers a significant safety advantage by reducing exposure to exhaust fumes and noise.

Hybrid vehicles play a particularly important role in this transition. Their compact designs and improved energy efficiency allow seamless integration with renewable power



sources, including mine-site microgrids. The use of electric motors provides smoother acceleration, faster response times, and enhanced traction control, which is especially valuable in wet or slippery headings where conventional drivetrains struggle.

At a strategic level, the adoption of electric and hybrid equipment represents one of the most significant shifts in modern mining. The benefits extend beyond cleaner air: they encompass the pursuit of zero-emission mining, reduced operating costs, and compliance with increasingly stringent environmental regulations. The pace of change is accelerating, and electrification is already demonstrating its effectiveness across haulage, drilling, and other core operations. The question now is how these technologies can be leveraged to help individual sites achieve their decarbonisation and sustainability objectives.

One of the most successful examples of hybrid mining machines in action is the Cummins – NHL NTH260 hybrid haul truck, which achieved a 15-20% reduction in fuel consumption during real-world field trials at the Baiyun Iron Mine in China.

Case Study: Cummins – NHL NTH260 Hybrid Haul Truck

- **Deployment:** First field-tested in 2024 at the Baiyun Iron Mine (Baogang Group, China).
- **Machine Specs:** 220 metric-ton payload mining truck, powered by a downsized Cummins QSK50 engine (2,000 HP) paired with hybrid battery technology.
- **Performance Results:**
 - Operated over 2,500 hours during the trial.
 - Achieved 15-20% lower fuel consumption, directly reducing carbon emissions.
 - Maintained reliability under continuous operation (12 hours/day, 7 days/week).
 - Impact: Allowed downsizing from a 2,500 HP engine to a 2,000 HP engine without loss of productivity.
 - Operator Feedback: Mine operators reported measurable improvements in productivity and cost efficiency, confirming hybrids as a strong bridge solution toward zero-emission haulage.

Cummins Inc. has commissioned its diesel hybrid solution in partnership with one of China's leading rigid mining truck manufacturers, North Hauler Joint Stock Co., Ltd. (NHL), demonstrating progress in decarbonisation for industrial customers.



The hybrid NHL NTH260, a 220 metric ton payload mining truck, rolled off the production line in January and is headed to Baiyun Iron Mine of Baogang Group, China, to begin field testing. As a leading power solutions provider, Cummins' optimised hybrid system allows the truck engine to be downsized from the previous 2,500HP QSK60 to the current 2,000HP two-stage QSK50.

"We're excited to share this significant milestone in our journey to advance bridge technologies and provide our mining customers with innovative, practical decarbonisation solutions," said Jenny Bush, Cummins Power Systems President, who joined key leaders from Cummins Power Systems China for the commissioning ceremony in the NHL industrial park in Bautou, China.

The truck is expected to provide a leading total cost of ownership based on initial cost advantages, fuel efficiency and extended service life of the engine. Improved fuel efficiency directly correlates to emissions and GHG

reduction. Advanced hybrids have the potential to improve fuel efficiency up to 30% dependent on the mine profile and advanced battery technology and controls integration.

"Our partnership with Cummins spans 40 years and advancing the hybridisation of our equipment is another demonstration of what we can accomplish together for the benefit of miners globally," said Haiquan Guo, General Manager, NHL. NHL produces trucks with payload range from 35 to 360 metric tons, with Cummins as the standard engine configuration."

"We are intent on enabling multiple pathways to carbon neutrality for industrial markets, including both first-fit and retrofit solutions," said Molly Puga, Cummins Power Systems Executive Director of Strategy, Digital and Product Planning. "It's partnerships with our customers like NHL and Baiyun Iron Mine that will accelerate product availability in the market and make both near- and long-term carbon reduction goals attainable."



EPIROC HYBRID UNDERGROUND TRUCKS & LOADERS:

- In partnership with Gold Fields Australia, Epiroc developed the MT65 E-Drive hybrid underground truck (65-ton class) for trials at the Granny Smith Mine in Western Australia.
- Byrnecut, a major underground contractor, also partnered with Epiroc to test diesel-electric hybrid loaders, aiming to reduce emissions and improve fuel efficiency without requiring new charging infrastructure.
- Hybrid Energy Systems in Mining Operations:
 - At the B2Gold Fekola Mine in Mali, the world's largest off-grid hybrid energy system was deployed. It combines solar PV, battery storage, and thermal generation to power 24-hour operations.
 - This system reduced reliance on heavy fuel oil, cut emissions, and ensured reliable electricity supply in a remote location.



Case Study: Autonomous Haulage with Epiroc Deep Automation and the Minetruck MT65 S

OVERVIEW

Epiroc's Deep Automation platform has been deployed to enable continuous autonomous haulage in underground mining environments. The system allows fleets of mine trucks to operate on closed hauling loops even during blasting cycles and while ventilation systems are clearing blast fumes. This capability addresses one of the most significant downtime factors in underground operations, extending productive machine hours and improving overall fleet utilisation.

SYSTEM DESIGN AND SAFETY FEATURES

The Minetruck MT65 S, integrated with Deep Automation, is engineered for large-scale underground haulage. Safety remains central to its design, with features such as automatic brake testing, neutral brake application, and hill descent assist. These functions reduce operator risk and enhance control in challenging ramp conditions. Importantly, the MT65 S maintains the highest payload capacity in its class without compromising safety standards, directly contributing to higher productivity per cycle.

Performance Enhancements

- **Drive train Improvements:** The updated drivetrain enables higher ramp speeds both uphill and downhill, increasing the number of haul cycles achievable per shift.
- **Energy Efficiency:** Optimised fuel consumption reduces operating costs and improves energy efficiency, aligning with industry goals for lower emissions and sustainable operations.
- **Reliability:** Extended component life, a re-designed electrical system, and improved component protection contribute to higher machine availability and reduced maintenance downtime.

DIGITAL INTEGRATION

The Rig Control System (RCS) and associated telematics provide real-time operational data, enabling predictive maintenance and performance optimisation. Operators manage autonomous fleets from remote control centres, eliminating exposure to hazardous underground environments during blasting and ventilation periods. This integration of automation and telematics ensures that the full potential of the machine is consistently realised.

OPERATIONAL IMPACT

By combining Deep Automation with the MT65 S, mining operations achieve:

- Continuous autonomous haulage loops with minimal interruption.
- Increased productivity through higher payloads and faster cycle times.

- Reduced fuel consumption and operating costs.
- Enhanced worker safety through remote operation and advanced braking systems.

This case demonstrates how automation and machine design improvements can work together to extend productive hours, lower costs, and improve safety in underground mining.

Mining operations are undergoing one of the most significant equipment transitions in decades. Hybrid and battery-electric machines are now central to strategies for reducing emissions, improving underground air quality, and lowering operating costs. While both technologies aim to decarbonise haulage and support sustainability targets, their engineering designs, operating environments, and cost structures differ in important ways.

HYBRID AND BATTERY-ELECTRIC MINING MACHINES

Mining equipment is undergoing a fundamental transformation as operators seek to reduce emissions, improve underground air quality, and lower operating costs. Hybrid and battery-electric machines have emerged as two distinct but complementary pathways toward decarbonisation. While both technologies aim to enhance sustainability and productivity, their engineering designs, operating environments, and cost structures reveal important differences.

Hybrid mining machines are designed to integrate a downsized diesel engine with an electric drive and battery system. The diesel engine provides baseline power while the battery system supplies peak load and recovers energy through regenerative braking. This configuration has proven particularly effective in large-scale surface haulage, where duty cycles are long and payloads are heavy. Field trials of the Cummins – NHL NTH260 truck at the Baiyun Iron Mine in China demonstrated fuel savings in the range of 15 to 20%, achieved without compromising productivity. Hybrids offer immediate advantages by reducing fuel consumption and emissions while requiring minimal infrastructure changes. They also deliver higher ramp speeds and payload efficiency, making them attractive for open-pit operations. However, hybrids remain dependent on diesel fuel, and their emission reductions are incremental compared to full electrification. Maintenance complexity is also greater due to the dual power systems.

Battery-electric mining machines, by contrast, rely entirely on lithium-ion battery packs to power electric drivetrains. These systems deliver instant torque and regenerative braking, enabling strong performance in demanding underground conditions. Their greatest impact is observed in underground mining, where eliminating exhaust emissions reduces the need for costly ventilation upgrades and improves worker health. Battery-electric loaders, drills, and haul trucks also reduce noise levels, enhancing operator comfort and safety. Operating costs are lowered through

savings on ventilation and fuel, though the initial capital investment remains high. Charging infrastructure and battery replacement cycles present ongoing challenges, and range limitations restrict their use in extended surface haulage applications.

When comparing the two technologies, hybrids are best suited to surface mining environments where reliability and payload capacity are paramount, while battery-electric machines are most effective underground, where ventilation and safety considerations dominate. Hybrids reduce fuel consumption by a measurable margin and require little infrastructure, whereas battery-electric machines eliminate tailpipe emissions entirely but demand significant investment in charging systems and battery management. From a cost perspective, hybrids deliver moderate reductions in fuel costs with manageable maintenance requirements, while battery-electric machines involve higher upfront capital expenditure but yield long-term operating savings. Strategically, hybrids function as a transitional technology bridging diesel and full electrification, while battery-electric machines represent the long-term pathway to zero-emission mining.

Looking ahead, hybrids are expected to remain dominant in surface mining over the next decade, providing immediate efficiency gains while infrastructure for full electrification matures. Battery-electric fleets will continue to expand underground, where their health, safety, and ventilation benefits justify the investment. Together, these technologies form a dual-track transition strategy: hybrids as the bridge and batteries as the destination. Their combined adoption is accelerating the industry's progress toward zero-emission mining, ensuring that productivity, safety, and sustainability advance in parallel.

Mining Outlook

- **Hybrids** will continue to dominate in surface mining over the next decade, offering immediate efficiency gains while infrastructure for full electrification matures.
- **Battery-electric fleets** are expanding underground, where health, safety, and ventilation savings justify the investment.
- Together, these technologies represent a **dual-track transition strategy**: hybrids as the bridge, batteries as the destination.

CONCLUSION

Hybrid and battery-electric mining machines are not competing technologies but complementary solutions tailored to different mining environments. Hybrids provide a practical, lower-risk path to decarbonisation in surface operations, while battery-electric machines are already transforming underground mining by eliminating exhaust emissions and reducing ventilation costs. The combined adoption of both technologies is accelerating the industry's progress toward zero-emission mining.

RP will reshape SA's coal industry amid modest production gains

South Africa's Integrated Resource Plan (IRP) 2025 is set to significantly reshape the country's coal industry, the Minerals Council of South Africa has said, even as coal output rose 1.5% in September amid a broader mining recovery.

On a year-on-year bases, total mining production for South Africa increased by 1.2% in September, primarily driven by coal alongside platinum group metals and gold.

However, Bongani Motsa, acting chief economist for the Minerals Council, said that Eskom's coal consumption could flatten, posing significant disruptions for the coal sector, mainly as a result of the IRP.

"The IRP 2025 marks a pivotal shift, with no new coal-fired power plant build planned. Without technological interventions such as carbon capture and storage, Eskom's coal consumption could decline by approximately 60 million

tons by 2042," said Motsa.

This marked decline in coal uptake by Eskom "would have significant socio-economic implications, potentially undermining South Africa's ability to generate foreign exchange" earnings.

In 2024, coal exports alone generated over R113 billion in foreign exchange for South Africa.

The coal sector has notched up some recovery. Output grew 1.5% in September, contributing 0.4 percentage points to overall growth of the industry.

This was aided by marginal improvements in rail and port efficiencies, which supported coal exports. Shipments of the energy commodity climbed higher by nearly 1 million tons compared to the same period a year earlier.

"However, the IRP 2025, which excludes new coal-fired power plant build, is expected to significantly reshape the industry," said Motsa.

Major coal miners in

South Africa include Exxaro Resources and Thungela Resources.

With the IRP pivoting more on "expensive renewables" and given the need to invest in transmission infrastructure, address the municipal debt and service delivery crisis, the South African economy will likely "face a prolonged period of elevated electricity prices", which are afflicting local miners and manufacturers.

"From a mining perspective, the improvement noted by National Treasury on the performance of Eskom's ability to supply electricity and the uptick in Transnet's operational performance bode well for mining. Yet the sector still faces the threat of high electricity tariffs and slow reforms on the rail side," noted Motsa.

The gross value added by the mining sector contracted by 3% in the first half of the year relative to 2024. Transnet failed to achieve 60% of its targets

set to improve operational performance for this financial year and electricity tariffs have increased on average more than 900% since 2008.

"The mining sector, which employs around 468 000 people, remains under pressure," Motsa added.

South Africa's mining sector is likely to grow by 2.5% quarter-on-quarter in the third quarter of the current year a 4.7% growth in the earlier quarter.

Among the commodities that recorded year-on-year declines in September were iron ore, which was the most significant as it accounts for 16.41% of total mining production, iron ore output fell by 2.2%, largely due to plant maintenance at one of the country's major producers.

However, export volumes rose by 12.6% year-on-year to 6.8 million tons, reflecting improved rail logistics by Transnet. Other notable production declines included copper, manganese ore and nickel.





Tradelink Publications Ltd

Publishing and Website Services for the Mining Industry

+44 (0)1777 871007 | +44 (0)1909 474258 | gordon.barratt@tradelinkpub.com

Connecting with our audience – Best of both worlds

Putting our customers first

In 2023 Tradelink Publications Ltd made a substantial investment in digital marketing, reaching out to many thousands more who are mining professionals working within Mining Companies, Mining Operations and Mining Manufacturing industries.

Over the last year, we have extensively increased our database to give our advertisers more value for money by engaging with a far bigger audience than we ever imagined. The digital versions of both journals will be available to in excess of 18,000 mining and quarrying companies who will receive FREE digital copies for all employees, a digital copy will be sent directly to the provided email address/s. Receiving a digital copy will also enable access to our new look website www.mqworld.com where news, feature articles, case studies, video and past issues can all be accessed.

Our new look web site www.mqworld.com will include the following and much more.

- Operational mines... **one subscription and all employers will receive free digital copies for 12 months.**
- Access to all our digital journals.
- **Daily news service**, events calendar, access to social media platforms and company financial statements.
- **Web and Video links** (post your product videos on our home page).
- **Equipment manufactures** latest news and developments.
- **Buyers guide** link.
- **Latest commodities prices** (Powered by Kitco).
- **Education – Universities, Libraries, Colleges and Technical training**
- **establishments** (One annual subscription entitles all your students to receive digital copies free for 12 months.)
- **Case studies** (access is free and paid for).
- **Technical articles/white papers** (access free and paid for).
- **Have your say** – Open Q&A forum on topics affecting the industry.
- Recruitment section – **Mining positions worldwide** advertised for free on our platform.
- **MQWorld – Monthly Newsletter reaching out to over 100,000 mining contacts** (sponsored opportunity)
- User access to our **Mining Operations Database.**

Contact gordon.barratt@tradelinkpub.com for preferential rates in 2023 for advertising/article placement and subscriptions.

MINING & QUARRY WORLD



