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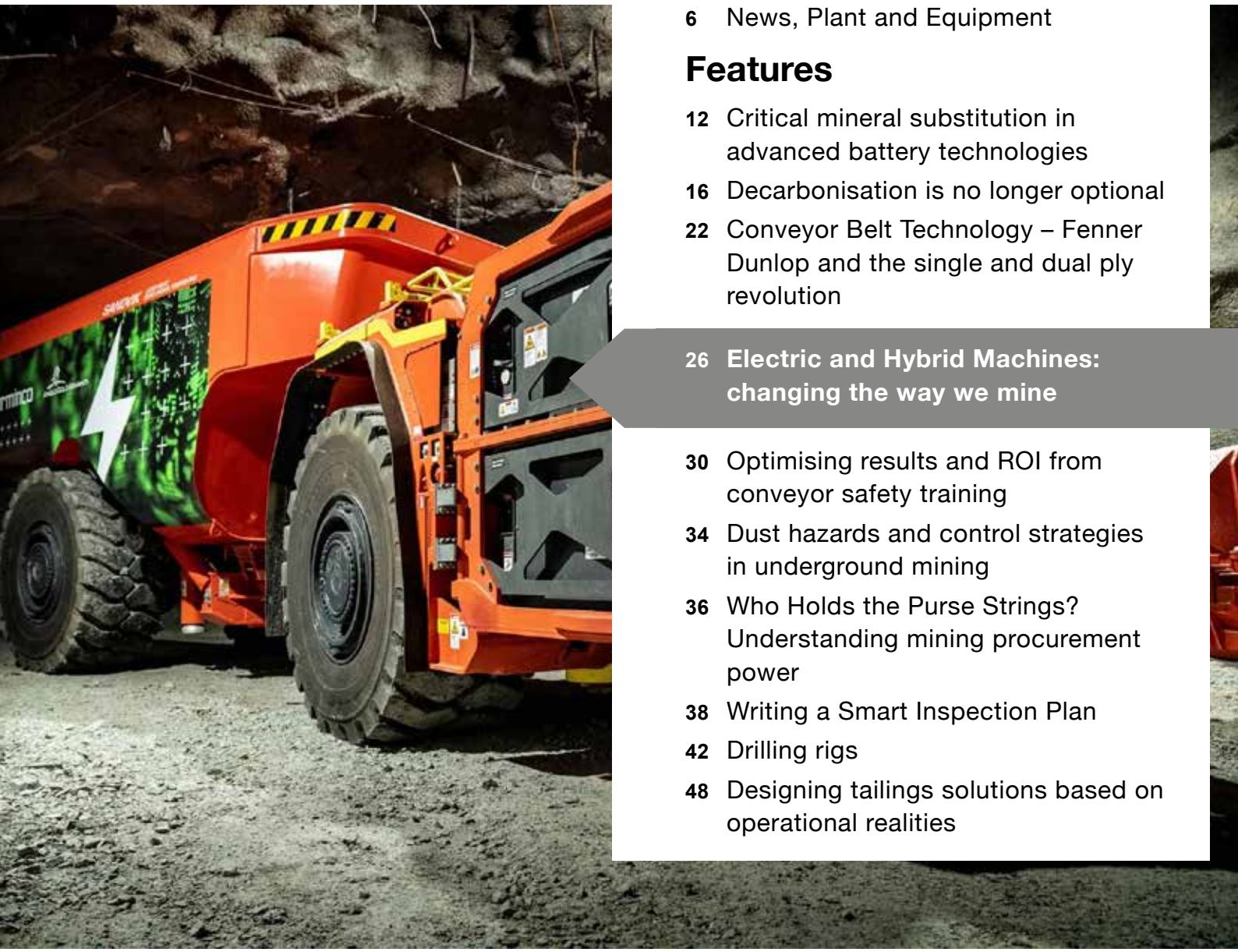

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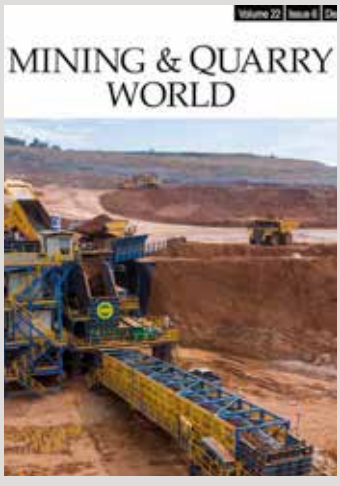

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EU unveils RESourceEU plan to shore up critical minerals supply, accelerate project development

The European Commission has adopted its RESourceEU Action Plan – a package of policy and financing measures aimed at reducing the bloc's dependence on external suppliers of critical raw materials and fast-tracking domestic and partner-country projects.

The plan builds on the recently enacted Critical Raw Materials Act (CRMA) and seeks to shield European industry from geopolitical shocks while boosting competitiveness across key value chains, including electric vehicles, defence, industrial motors, aerospace, AI chips, and data centres.

At the heart of the plan is a push to accelerate project permitting, mobilise up to €3-billion over the next 12 months for strategic supply initiatives, and create a new institutional architecture to coordinate supply chain resilience across the EU.

From early 2026, the Commission will establish a European Critical Raw Materials Centre to provide market intelligence, manage strategic project portfolios, and coordinate financing with public and private partners. The centre will also support joint purchasing and stockpiling – tools the Commission views as essential to protecting the Single Market from price spikes and geopolitical interference.

A Raw Materials Platform will aggregate industrial demand, facilitate collective procurement of strategic materials, and help secure offtake agreements. Work is also under way on an EU-wide approach to stockpiling, with a pilot system expected to be operational in early 2026.

To boost recycling capacity, the Commission will introduce export restrictions on permanent-magnet scrap and waste from early 2026, with similar actions for aluminium – and possibly copper – to follow. Amendments to the CRMA will expand labelling requirements and incentivise the use of recycled pre-consumer waste in permanent magnets.

The plan also foresees actions to reduce dependence on fertilisers made from critical minerals, with an EU fertiliser and nutrient-recycling plan due by mid-2026.

A key part of RESourceEU is the acceleration of EU-relevant projects through de-risking tools, streamlined permitting and regulatory reform. The Commission says the measures could reduce strategic dependencies by up to 50% by 2029.

Up to €3-billion will be mobilised over the next year for projects that can deliver alternative supply in the short term. Support has already begun flowing to priority initiatives, including Vulcan Energy's lithium-extraction project in Germany and Greenland Resources' Malmbjerg molybdenum project.

European Union Commissioner for International Partnerships, Jozef Síkela said the Malmbjerg project would help to develop a fully European supply chain and support industrial development in Greenland. "This project can meet all of Europe's defence needs for molybdenum and around a quarter of our total demand. With processing taking place inside the EU and long-term offtake agreements secured with European companies, it will create a fully European value chain and significantly reinforce our strategic autonomy."

To diversify supply chains and strengthen industrial cooperation, the EU will intensify engagement with its 15 existing strategic raw material partners, with South Africa the most recent addition. Negotiations will soon begin with Brazil, while dedicated investment frameworks are being advanced with Ukraine, the Western Balkans and the Southern Neighbourhood.

Under its Global Gateway initiative, the EU will pursue co-investment in projects across emerging markets. Brussels is also backing wider international coordination through the Canada-led G7 Critical Minerals Production Alliance and the G20 Critical Minerals Framework.

European Commission president Ursula von der Leyen originally announced the RESourceEU concept at the Berlin Global Dialogue in 2024, framing it as essential to safeguarding Europe's industrial base amid the "weaponisation" of critical raw materials by dominant suppliers.

'CLEAR SIGNAL'

The mining and processing sector has broadly welcomed the plan, with industry leaders saying the focus on early-stage financing, permitting reform and supply-chain diversification is long overdue.

Toronto-listed Rock Tech Lithium CEO Mirco Wojnarowicz said the package is "a clear signal from Brussels: Europe wants control over its raw materials supply back – and now."

"Particularly important is that the Commission recognises lithium for what it is: a strategic critical raw material, not only for e-mobility, but equally for large-scale battery storage and data centres as well as the defence industry," he said.

Wojnarowicz said RESourceEU provides tailwinds for Rock Tech's Guben lithium converter in Germany – recognised as a strategic project under the CRMA – noting that permits are in place, offtakers are lined up and cost-structure revisions have strengthened the project's path to a final investment decision.

"Europe now needs projects that deliver impact in the short term – and that is exactly what we can do. The Resource EU Plan brings together financing, co-ordination and political will with unprecedented clarity for the first time. What is crucial now is that the next step follows. We stand ready to build lithium value creation in Europe and thereby make an important contribution to strategic sovereignty," he said.

Rock Tech's Guben Converter, in Brandenburg, is slated to be Europe's first commercial lithium-hydroxide refinery. The facility will produce 24 000 t/y of battery-grade lithium hydroxide using spodumene concentrate sourced through trading partner C&D Logistics.

Eramet eyes manganese, lithium growth in turnaround plan

Eramet aims to deliver more manganese from Gabon and lithium from Argentina as part of efforts to strengthen its finances, which have been hit by falling profits and rising debt, the French mining group said recently.

The company, pressured by weak metal prices, production setbacks and the buyout of its lithium partner in Argentina, had pledged additional measures in early December after trimming capital expenditure.

Eramet aims to generate a boost to core earnings before interest, tax, depreciation and amortisation (Ebitda) of between €130-million and €170-million within two years, supported by rail infrastructure improvements in Gabon to expand volumes of transported ore, it said in a statement.

On top of the Ebitda target, the firm may also get a profit boost from the ramp-up of its lithium production in Argentina, with capacity expected to be reached by the end of 2026, it said.

Eramet has obtained a waiver on a December 2025 debt ratio covenant from its lending group, ensuring availability of its currently undrawn credit facility of €935-million, it said.

Efficiency steps including on capex should boost free cash flow by €60-million to €70-million by year-end, Eramet said, adding it was evaluating all strategic and financial options to accelerate its performance and deleveraging efforts.

Eramet, which confirmed 2025 volume targets, said it expected its markets to remain pressured by slowing Chinese industrial demand and global economic uncertainty, though conditions should show signs of stabilising in 2026 as supply and demand gradually rebalance.

Polymetals raises $34.4 million for Endeavor

Polymetals Resources has raised $34.4 million for its Endeavor silver zinc mine in New South Wales, received through the issue of new shares priced at $0.87 per share.

Polymetals executive chairman Dave Sproule thanked shareholders for their continued support, while welcoming new investors.

"We are particularly pleased to see significant interest from high-quality domestic and international institutions," Sproule said.

The company received commitments from domestic and international institutional and sophisticated investors under the placement to raise the amount through the issue of 39,500,000 new fully paid ordinary shares.

"Polymetals anticipates a strong period of news flow supported by rising production cashflow and ongoing exploration success from near-mine and regional targets."

The company said the funds will be used to accelerate near-mine drilling at Carpark, as well as drill testing high-priority silver-zinc and copper targets within the mining leases.

Additionally, it aims to fast-track regional exploration with the drilling of silver-lead-zinc, gold and copper-gold targets, as well as strengthen the balance sheet alongside the recently announced additional standby credit facilities.

The $0.87 per new share price represents a 15.9% discount to the company's last traded price of $1.035 on Friday, November 28 2025, a 6.8% discount to the five-day volume-weighted average price (VWAP) of $0.934.

"Across the March quarter of 2026, mining rates will increase materially from the high-grade silver Upper North Lode, with the company well placed to take advantage of strong silver pricing."

Polymetals shares resumed trading on the ASX market in December, with settlement of the placement expected on Wednesday, December 10, and allotment of new shares on the following day.

The capital raise comes four weeks after the company recommenced operations at Endeavor in the wake of the sudden and tragic loss of two employees, Holly Clarke and Patrick 'Ambrose' McMullen, in an incident at the mine.

Vale, Glencore to explore $2bn joint copper development in Sudbury

Vale Base Metals (VBM) and Glencore Canada have signed an agreement to evaluate a potential $1.6-billion to $2-billion brownfield copper project that will combine deposits on their neighbouring properties in the Sudbury basin, paving the way for what could become one of the region's most significant new copper developments in decades.

Under the framework agreement, the companies will study whether they can jointly mine their underground copper deposits by using existing infrastructure at Glencore's idled Nickel Rim South mine, including deepening the current shaft and driving new drifts to reach ore bodies on both sides of the property boundary.

The proposed project could deliver about 880 000 t of copper over 21 years, alongside nickel, cobalt, gold and platinum-group metals typical of Sudbury's polymetallic geology.

Engineering, permitting and consultation work is planned for 2026, with a final investment decision targeted in the first half of 2027.

"Opportunities to partner and unlock synergistic value between neighbouring miners in the Sudbury basin have been pursued for decades, without meaningful success," Vale Base Metals CEO Shaun Usmar said. "I'm grateful for the commitment shown by both Glencore and our VBM team for coming together to finally unlock this historic opportunity by demonstrating a new collaborative way of working.

"The contemplated partnership paves the way to extract valuable copper-rich orebodies for our respective operations that would otherwise be lost to both companies," he added, saying the plan could secure benefits for local communities and deliver earlier critical mineral supply for Canada's economy.

If the study phase is successful, Vale Base Metals and Glencore intend to form a 50:50 joint venture to advance the project.

UK has no immediate plans for critical minerals price floor, Minister says

Britain has no plans to match the United States in supporting domestic rare earth companies with a price floor to cut reliance on dominant producer China, Industry Minister Chris McDonald said.

So far Britain is attracting adequate investment in the critical minerals sector to develop home-grown supply, but it will monitor the situation in case other mechanisms are needed.

Group of Seven (G7) members and the European Union are considering price floors to promote rare earth production, as well as taxes on some Chinese exports to incentivise investment, sources said in September.

The US provided a guaranteed minimum price to rare earths group MP Materials in July as part of a multibillion-dollar investment by the Pentagon and sources told Reuters the mechanism would likely be extended to other firms.

Recently, McDonald met with US Pentagon officials in London, who outlined their support policies for critical minerals, including the price floor.

"We're doing most of them but we're not doing all of them, and a price floor is one of them that's currently not on our list. But maybe I'll keep an eye on how that goes," he said in an interview.

"Ultimately for me it's about can we attract this investment, and at the moment we are attracting the investment."

Britain launched its critical minerals strategy recently, which set targets to meet 10% of domestic demand from UK mining and 20% from recycling by 2035, backed by up to 50-million pounds in funding.

China accounts for about 70% of rare earth mining and 90% of refining.

Britain, which currently produces 6% of its critical mineral needs domestically, is focusing its strategy on lithium, nickel, tungsten and rare earths.

Britain expects lithium processing projects in northern England to break ground within the next few years and aims to produce at least 50 000 metric tons of lithium by 2035.

The country also plans to include stockpiling of critical minerals in its defence procurement plan.

Tasmania emerges as rare earths hub

Tasmania is emerging as a key player in the global race for critical minerals after ABx Group produced a mixed rare earth carbonate (MREC) sample from its Deep Leads project.

According to ABx Group, it found the project had more than twice the proportion of high-value dysprosium (Dy) and terbium (Tb) found in any comparable deposit outside China.

Developed with the Australian Nuclear Science and Technology Organisation (ANSTO), the maiden MREC contains 4% Dy and 0.7% Tb as a percentage of total rare earth oxides (TREO).

The heavy rare earth content is 2.8 to 4.7 times higher than peer MRECs and yields a calculated basket price up to 51% greater than competitors.

"This is one of the most significant achievements of our rare earths project and we are simply delighted with this result, especially since it is our first MREC product and there is significant scope for optimisation," ABx managing director and chief executive officer Mark Cooksey said.

"We've been eagerly anticipating confirmation of this MREC product, which is simply the best we know of from any ionic rare earth resource outside of China.

"The ABx MREC is likely to be particularly sought after by customers seeking high DyTb and low uranium and thorium."

Deep Leads hosts an estimated 89 million tonnes (Mt) at 844ppm TREO, including some of the highest Dy/Tb concentrations recorded in an Australian clay-hosted deposit.

These elements are essential for magnets used in electric vehicles, wind turbines, robotics and defence technologies, and faces the most acute supply risk globally due to China's dominance.

Ascot warns of potential CCAA filing as restructuring talks stall

Ascot Resources, owner of the Premier gold mine in British Columbia, has warned it may be forced to seek creditor protection after failing to finalise terms for a planned C$150-million private placement and secured creditor restructuring.

The company said that trading in its shares was halted on November 28 ahead of an expected announcement on pricing and other terms for the financing package first outlined on October 23. However, negotiations did not reach agreement and Ascot said it had "no additional information to announce at this time".

With structure and pricing still unresolved, Ascot said the private placement was no longer certain to proceed. Should the financing fail, the company would have to explore other options, including proceedings under the Companies' Creditors Arrangement Act (CCAA), though it stressed there was no assurance that any alternative would be available.

Ascot reported a cash balance of C$1.9-million as of December 1 and expected to be able to fund current operations only until mid-December.

Fortescue delivers large-scale battery storage to the Pilbara

Fortescue has marked a major milestone in its mission to decarbonise iron ore operations in the Pilbara thanks to the delivery of its first-ever large-scale battery energy storage system to North Star Junction.

The installation is the first in a planned four-to-five gigawatt-hour rollout of energy storage systems required to help decarbonise the company's energy supply over the coming years.

The infrastructure is powered by renewable energy vehicle manufacturer BYD's blade battery technology and will store renewable energy during the day for green power to be supplied overnight to Fortescue's Pilbara Energy Connect network.

BYD blade batteries are said to be engineered for high safety, reliability and performance; featuring liquid cooling systems designed to operate efficiently in the Pilbara's wide range of temperatures and conditions.

The installation comprises of 48 energy storage containers, providing a total capacity of 250 megawatt hours and capable of delivering up to 50 megawatts of power for five hours.

"Fortescue is leading one of the most ambitious mining decarbonisation programs in the world, and BYD is proud to support this transformation," general manager of BYD energy storage and new battery application Yin Xueqin said.

"The North Star Junction battery energy storage system is an important milestone for our partnership, and we will continue working closely with Fortescue to deliver the large-scale storage needed to power a green Pilbara."

Fortescue is deploying renewable energy infrastructure to help reach its goal of Real Zero by 2030 with the company's next battery energy storage system set to be built at Eliwana in early 2026.

Lucara awards last major Karowe underground contract

Lucara Diamond Corporation has awarded a lateral development contract for its Karowe underground project (UGP), in Botswana, to Group R Mining and Exploration Botswana.

The contract includes all underground lateral development from the production and ventilation shafts to the orebody, including construction of the extraction level, underground crushing chamber, fine ore bins, pump stations with associated vertical dams, drilling horizons, workshop facilities and all connecting infrastructure required to advance development toward the kimberlite.

"We are pleased to announce the award of this critical contract to Group R, marking an important milestone in the continued development of our underground project. The award of the last major contract for the UGP reflects our commitment to maintaining momentum on the project and delivering the project safely, responsibly and in accordance with our schedule.

"We are confident that Group R's expertise and proven record will support our vision for a world-class underground mine," comments Lucara president and CEO William Lamb.

"We are honoured to partner with Lucara on this crucial phase of the Karowe UGP. Our team is dedicated to upholding the highest standards of safety, quality and operational excellence as we collaborate to open the next chapter of this world-class asset.

"We look forward to using our expertise and contributing to the long-term success of the mine and the communities it benefits," adds Group R CEO Hannes van Staden.

Group R is expected to mobilise to site in the second quarter of 2026, with lateral development work to start in July 2026.

Recruitment and work permits would start in early 2026, with a focus on local employment.

Lucara has initiated detailed engineering of the lateral development portion of the UGP and is finalising an updated life-of-mine plan based on the results of the simulation work.

First shipment from Kodal's Bougouni project departs San Pedro port

Aim-listed Kodal Minerals' maiden shipment of 28 950 t of lithium spodumene concentrate (vessel capacity) has completed loading onto a dedicated bulk cargo vessel at the Port of San Pedro, in Côte d'Ivoire.

The vessel arrived on November 9 and the loaded vessel subsequently departed on November 30, bound for the destination port in Hainan province, China.

Following completion of loading, Kodal's Mali-registered mining company, Les Mines de Lithium de Bougouni (LMLB), will submit an invoice for the initial 95% of the cargo value with the offtake partner, Hainan Mining.

LMLB is subsequently due to receive the first payment from this shipment for a total expected value of about $24-million.

The focus of LMLB's operations over the recent weeks has been the transport of over 30 000 t of lithium spodumene concentrate from the Bougouni lithium project in Southern Mali to its dedicated stockpile facility at the Port of San Pedro, an about 880 km road journey, ahead of first shipment.

This successful transport operation, as well as the subsequent loading and departure of the vessel from the port, highlights the effectiveness of the transport route, Kodal Minerals avers.

To date, the Stage 1 dense media separation (DMS) processing plant at Bougouni has produced over 45 000 t of lithium spodumene product, grading an average lithium oxide content of 5.39%.

"The completion of the loading and the departure of our first shipment of lithium spodumene concentrate to our joint development and offtake partner, Hainan, is a major milestone for our team and will result in the receipt of the first revenues from the project," Kodal Minerals CEO Bernard Aylward highlights.

"Additionally, the significant improvement in the lithium pricing environment in recent weeks will be reflected in the sale price for our spodumene concentrate as per the terms of the offtake agreement.

"The final sale price for the lithium spodumene product will be adjusted to account for the actual grade and quality of product delivered and deducting the cost of sea freight, the company expects the price to exceed $930 per dry metric tonne of spodumene concentrate," he informs.

"I would like to thank all of our stakeholders who have made this critical step possible – our loyal shareholders, dedicated workforce, supportive Malian stakeholders, including the Malian government, the office of the governor of the Bougouni region and the entire Bougouni community, many of whom are among the 650-strong team on site at Bougouni.

"Additionally, I would like to thank Hainan for its unwavering support of the project as our joint development and offtake partner, without which a momentous achievement would not have been possible," Aylward adds.

Construction on the Bougouni project started in mid-2024 and the mine has produced over 45 000 t of spodumene to date.

The Stage 1 DMS processing plant processes coarse-grained spodumene material sourced from the Ngoualana mine, with a planned feed of one-million tonnes a year of lithium ore into the DMS processing plant.

The project is the second-only lithium mine in Mali.

Vinacomin signs coal supply contract with Laos

Two subsidiaries of Vietnam National Coal and Mineral Industries Holding Corporation Limited (Vinacomin), Vinacomin Coal and Mineral Import–Export Joint Stock Company and Vinacomin–Northern Coal Trading Joint Stock Company, signed a coal supply contract with Laos' Xekong Power Plant Limited, a subsidiary of Phonesack Group, at Vinacomin headquarters recently.

The signing comes as Laos prepares to celebrate the 50th anniversary of the National Day of the Lao People's Democratic Republic, highlighting the significance of the traditional, close and trustworthy cooperative relationship between the two countries.

The agreement is the result of thorough discussions and negotiations between the parties and opens a new phase of co-operation in coal trade between Vinacomin and energy companies in Laos.

It affirms Vinacomin's role in expanding markets and ensuring stability and efficiency for the group's production and business activities.

Previously, the Minister of Industry and Trade of Việt Nam and the Minister of Energy and Mines of Laos signed a cooperation agreement between the two governments on the trade of coal and electricity in Vientiane, Laos recently.

This document is strategic and lays the foundation for long-term cooperation between the two countries in the energy and mineral sectors.

Gold explorers up their spending: new data

Australian gold exploration expanded by 45% over the 12 months to September 30, fuelled by significant increases in activity in New South Wales and South Australia.

According to the Australian Bureau of Statistics quarterly data for mineral exploration and expenditure, the third quarter saw a 7.2% increase in gold exploration spending, up to $431.5 million. Across all minerals, some $1.07 billion was spent in the quarter, a 5.7% increase quarter-on-quarter, and the highest quarterly spend since the fourth quarter of 2023.

Total metres drilled for the September quarter was 2,835.5 km, down 1.5% on the previous quarter, but 8.5% higher than over the same period in 2024.

On the production side, gold producers have also had an enviable quarter. The sector produced 76 tonnes of the precious metal over the three months to September 30, that output almost anticipating a surge in prices over the next few months.

The Association of Mining and Exploration Companies (AMEC) has welcomed the new data showcasing the mining industry in Australia.

AMEC chief executive officer Warren Pearce said the gold sector was a particular standout.

"Gold has proven itself to be an outstanding and resilient performer in maintaining explorer interest, buoyed obviously by recent gold price highs and the continuing uncertainties seen in global markets," Pearce said.

"As an industry, it is critical we continue to build a pipeline of discoveries, and this requires a dollar commitment to green fields exploration, and a recognition by governments.

Site chosen for water project set to underpin BHP copper ambitions

The South Australian government has chosen Mullaquana station, near Whyalla, as the preferred site for the Northern Water desalination plant, clearing the way for planning on a project seen as critical to BHP's long-term copper strategy.

The location, about 20 km south of Whyalla, emerged as the most suitable following a multi-criteria analysis comparing Mullaquana station with Cape Hardy on the eastern Eyre Peninsula.

The assessment weighed economic, social and environmental considerations, as well as project deliverability. The preferred site also removes the need for about 200 km of pipeline infrastructure, reducing both cost and environmental impact.

The selection enables planning, procurement and statutory assessment activities to progress for the Northern Water project, which is intended to supply industrial users across the Upper Spencer Gulf and Far North. The project is expected to support more than 4 000 jobs a year during construction and deliver billions of dollars in annual economic benefits if it proceeds to development.

At the same time, Northern Water has shortlisted two major consortia to advance to the next phase of the competitive procurement process. WaterConnector, comprising Acciona Construction Australia and Acciona Agua Australia, and Watermark, including Clough (Webuild Group), Fisia Italimpianti (Webuild Group), CPB Contractors and Sacyr Water, will now prepare detailed bids to design, build, operate and maintain the desalination plant and associated pipeline infrastructure.

Nearly 40 organisations responded to the initial registration of interest, with several consortia subsequently invited to lodge expressions of interest. A market-tested proposal will ultimately inform a final investment decision, expected in the 2026/27 financial year.

Project costs would be recovered through future commercial offtake agreements, principally with BHP.

South Australia hosts almost 70% of Australia's economic copper reserves, but BHP's operations are increasingly constrained by groundwater availability.

In February 2024, BHP joined the South Australian government and industry partners in announcing that the Northern Water project would progress to the next phase of study.

"Global demand for copper is growing fast, and the opportunity for South Australia is significant," BHP asset president copper South Australia Anna Wiley said at the time.

"BHP has created an integrated copper province that we hope will bring the scale required to economically and sustainably produce and process more copper here in South Australia and deliver it to global customers.

"The Northern Water Supply Project will support our South Australian copper operations and growth ambitions."

Glencore to ship first cobalt cargo under Congo's new quota system

Glencore has become the first miner to export cobalt under Democratic Republic of Congo's (DRC's) new quotas, sending a small initial shipment to test the system, one government source and two trade sources familiar with the matter explained recently.

Congo cleared Glencore's shipment pending payment of a 10% royalty, the government source said, marking the beginning of a return to exports after a months-long ban that has driven cobalt prices sharply higher and squeezed availability of the metal needed for electric vehicles.

The central African country accounts for more than 70% of global mined production that is estimated by analysts at around 280,000 metric tons this year. The system, launched on October 16, has allocated a quota of 18 125 metric tons for the fourth quarter and will cap annual exports at 96 600 tons from 2026.

Cobalt traders initially expected shipments to smelters by January after Congo introduced the quota system, but have since decided it will take longer, two separate trade sources said. The first full-sized shipment from Congo is now expected by April.

China's cmoc and Glencore receive largest allocations

China's CMOC and Glencore, the world's two largest cobalt-producing companies, received the largest quota allocations. CMOC's quota for the fourth quarter is 6 650 tons and Glencore's 3 925 tons.

Congo's regulator ARECOMS retains 10% for its strategic reserve.

CMOC's Tenke Fungurume Mining has also started the processes to start exports, the government source said.

Glencore declined to comment. CMOC did not immediately respond to request for comments. Neither did ARECOMS and Congo's mines ministry.

"We authorised the release of the first shipment by Glencore as a pilot process. However, the procedure is still under way to determine the quality and reach a final decision on the quantity that will be exported," the government source said. The 10% royalty will be paid after the quality determination.

"Once someone does a first export, the second will become much easier," the source added. None of the sources could be named because they were not authorised to speak publicly on the issue.

While Congo's government has threatened penalties for non-compliance, shipments have yet to begin as exporters struggle with unclear procedures and payment requirements.

Mining lobby has sought urgent talks to tackle delay

Reuters previously reported that the country's mining lobby called for urgent talks to clarify legal ambiguities and compliance hurdles. It said the new requirements – including a 10% royalty prepayment within 48 hours and a compliance certificate before any cargo moves – could delay exports and disrupt global battery supply chains.

Glencore, which operates the Mutanda and Katanga mines in Congo, favoured a quota-based export system while CMOC had sought a full lifting of the ban.

Under the new rules, exporters must notify authorities, prepare batches for sampling and wait for lab tests to certify quality and volumes before royalties are calculated and paid.

Without proof of payment, a cargo cannot move.

Cobalt metal prices are trading around $24 a lb or $52 900 a ton. That compares with nine-year lows around $10 a lb in February when Congo announced the suspension of cobalt exports.

Thiess wins $700 million Eva copper deal with Harmony Gold

Global mining services provider Thiess has secured an alliance agreement with Harmony Gold Mining to deliver multiple packages of work at the Eva copper mine project in northwest Queensland.

The package of work includes bulk earthworks, workshop construction and mining services over five years, with the scope of works valued at approximately $700 million.

Works at the site are set to help Harmony further optimise the projects following the results of an updated feasibility study at the site being released last month, with the mine expected to produce around 60,000 tonnes of copper and 14,000 ounces of gold per annum over its estimated 15-year mine life.

"The Eva Copper Alliance Agreement aligns Thiess and Harmony strategically and operationally – enabling us to set new benchmarks for sustainable, efficient copper development at what will be the largest copper mine in Queensland," Thiess Group chief executive officer Michael Wright said.

"Thiess' strategy to diversify our commodities portfolio is further progressed with this copper contract award, a critical metal that enables the world's transition to low emissions energy."

Early stage works for the project are already underway, with bulk earthworks and civil works in progress since May 2025.

"The Eva copper mine project is integral to Harmony's strategic objective to become an international gold and copper producer," Harmony chief development officer Johannes Van Heerden said.

"Through the Eva Copper Alliance, Thiess and Harmony combine their strengths in a single, integrated framework – leveraging technical expertise, proven industry experience, and shared values to achieve common objectives."

Once construction is completed, Thiess will provide mining services from June 2026 through to June 2031, delivering drill and blast, mine planning, technical services, mining operations and mobile equipment maintenance across multiple open pits.

Critical mineral substitution in advanced battery technologies

The global energy transition, underpinned by the widespread adoption of Electric Vehicles (EVs) and grid-scale energy storage, has exponentially increased the demand for critical minerals (CMs) such as lithium, cobalt, nickel, and graphite. This surging demand, coupled with concentrated geopolitical supply chains and environmental concerns associated with extraction, has created a fundamental material science imperative: to innovate in **critical mineral substitution** and reduce dependence on vulnerable materials. The focus has thus shifted toward next-generation battery chemistries and designs that promise comparable or superior performance with a more resilient and sustainable material footprint.

Gordon Barratt of Mining & Quarry World takes a detailed look at the materials and technological challenges created by this transition.

THE CHALLENGE OF SUBSTITUTION IN LITHIUM-ION CHEMISTRIES

The established dominance of Lithium-ion Batteries (LIB's), particularly those utilising Nickel-Manganese-Cobalt (NMC) cathodes, makes CM substitution a complex material science challenge. Substitution is not merely a component swap; it requires maintaining the delicate electrochemical stability, energy density, and cycle life that existing LIB's offer.

Cobalt Reduction: Cobalt is particularly problematic due to its high cost and the ethical and geopolitical risks associated with its mining. Material science advancements have primarily focused on developing high-nickel cathodes (e.g., NMC 811), which drastically reduce cobalt content while increasing energy density. However, this substitution introduces a trade-off: higher nickel content can compromise thermal stability and decrease the battery's

Lithium

Cobalt

Nickel

lifespan, necessitating complex engineering solutions in cell design and electrolyte formulation to maintain safety and performance.

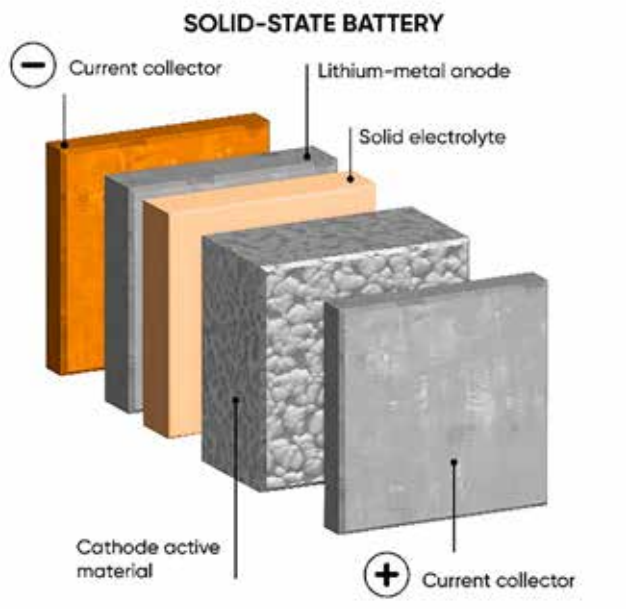
Anode Innovation: Another area of material innovation is the anode. Graphite currently dominates, but research is intensely focused on partially or fully substituting it with materials like silicon. Silicon can store significantly more lithium ions per unit of mass, theoretically boosting energy density by up to 20%. The material science challenge here is managing the volumetric expansion of silicon during charging and discharging, which rapidly degrades the anode structure and shortens the cycle life. Solving this requires novel binders, nano-structuring of silicon particles, or integrating silicon into composite anodes.

EMERGING ARCHITECTURES: SOLID-STATE AND SODIUM-ION

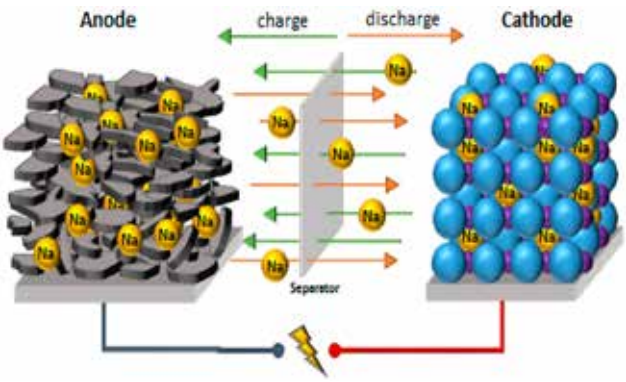
The most disruptive forms of substitution involve entirely new battery architectures that fundamentally reduce or eliminate the need for certain CM's.

Solid-State Batteries (SSB's)

SSB's replace the flammable liquid electrolyte of traditional LIB's with a solid material, enabling the use of a lithium-metal anode. This substitution, while increasing the requirement for lithium itself (due to the use of a high-capacity Li-metal anode), allows for the potential reduction



Solid State Battery



Sodium-ion Battery

or elimination of nickel and cobalt in the cathode, often opting for materials like Lithium Iron Phosphate (LFP) or high-voltage spinel compounds. The material science hurdle in SSB's is achieving high ionic conductivity in the solid electrolyte – ceramic, polymer, or sulphide – and maintaining a stable, low-resistance interface between the solid electrolyte and the electrodes. A poor interface can cripple performance, making this a pivotal R&D focus.

Sodium-Ion Batteries (SIB's): SIB's offer a direct form of substitution by replacing lithium with the highly abundant and globally distributed sodium. The use of sodium, approximately 1,000 times more abundant than lithium in the Earth's crust, dramatically mitigates supply chain risks and cost volatility. SIBs typically utilise more readily available cathode materials like sodium-based layered oxides or Prussian blue analogues, avoiding reliance on expensive cobalt and often nickel. The primary material science challenge for SIBs lies in energy density. Due to the larger size and heavier mass of the sodium-ion compared to the lithium ion, SIB's inherently have a lower energy density, which currently limits their application primarily to grid storage and lighter, cost-sensitive EVs. Future success hinges on material breakthroughs that can increase their gravimetric and volumetric energy density beyond the current range of 100-160 Wh/kg.

THE STRATEGIC TRAJECTORY FOR A RESILIENT FUTURE

The pursuit of CM substitution is a strategic necessity for a sustainable energy future. While Lithium Iron Phosphate (LFP) batteries have already achieved a significant market share by substituting cobalt and nickel for abundant iron, the next generation of solutions – SSB's and SIB's – will define the long-term material landscape. These innovations, coupled with advancements in mineral recovery and recycling (circularity), form a comprehensive strategy to manage the energy-minerals nexus. Material science is therefore not just improving the performance of a product, but fundamentally redesigning the industrial foundation of the energy transition, shifting from scarcity and geopolitical risk toward abundance and resilience.

THE STRATEGIC IMPERATIVE FOR SUSTAINABLE MATERIALS IN THE ENERGY TRANSITION: INNOVATION, CIRCULARITY, AND GOVERNANCE

The global energy transition, necessary to mitigate anthropogenic climate change, relies fundamentally on advanced energy storage technologies. While this transition promises environmental benefits, its very foundation is creating a secondary crisis rooted in the supply chain of critical minerals (CM's). These materials, essential for batteries, solar panels, and wind turbines, carry significant environmental and social externalities. Addressing this complex challenge requires a multi-faceted approach, integrating breakthroughs in material science, systemic advancements in circular economy principles, and robust policy interventions to ensure the energy transition is equitable and truly sustainable.

THE NEXUS OF MATERIAL SCIENCE AND EFFICIENCY: NEW LITHIUM SALTS

The core efficiency and durability of modern energy storage systems, particularly lithium-ion batteries (LIB's), are inextricably linked to the performance of the **lithium salt** component within the electrolyte. While much battery research has centred on enhancing active cathode materials or optimising electrolyte matrices, the potential of

the lithium salt remains a pivotal, yet often underexplored, field of innovation. The salt, which must provide adequate ionic conductivity and maintain electrochemical stability across varying thermal and operational conditions, is crucial for meeting escalating demands for high capacity and extended lifetime.

Current industry standards are dominated by salts such as lithium hexafluorophosphate in liquid electrolytes and lithium bis (trifluoromethanesulfonyl) imide in polymer systems. However, these salts exhibit limitations, notably poor thermal stability and corrosive degradation pathways that compromise long-term battery durability. The search for alternative salts featuring more stable and less corrosive anions is critical. Success in this area will enable superior **cyclability** and significantly reduced degradation of internal cell components. This innovation directly impacts sustainability by optimising cell performance, thereby reducing the frequency of battery replacement and minimising the environmental burden associated with production and disposal.

WHAT ARE LITHIUM SALTS?

Lithium salts are chemical compounds that contain lithium ions (Li+) combined with other elements. These salts are typically white, crystalline powders that dissolve in solvents to form electrolytes used in lithium-ion batteries.

The most common lithium salts include:

- Lithium hexafluorophosphate ($LiPF_6$)
- Lithium bis(trifluoromethane sulfonyl)imide (LiTFSI)
- Lithium tetrafluoroborate ($LiBF_4$)
- Lithium perchlorate ($LiClO_4$)

These salts are unlike the table salt (sodium chloride) you use in food. Instead, they are carefully engineered substances that play a vital role in battery chemistry.

IS LITHIUM A SALT?

Yes and no – lithium is not a salt, but it forms salts when reacting with other elements. Lithium is a soft, silver-white metal belonging to the periodic table's alkali metal group. When lithium forms a compound with a non-metal or a negatively charged ion, it becomes a lithium salt.

So, when people ask, "Is lithium a salt?" the precise answer is:

Lithium is a metal that forms salts when combined with other chemical compounds, especially in battery electrolytes.

MITIGATING ENVIRONMENTAL AND SOCIAL EXTERNALITIES OF EXTRACTION

The rising global demand for CM's has amplified the environmental and social costs associated with primary mineral extraction. Mining activities often lead to water depletion, extensive land use change, and widespread pollution, resulting in significant loss of biodiversity and degradation of natural resources. These ecological impacts directly threaten the well-being and subsistence of local communities. Of particular concern is the overlap between CM deposits and indigenous lands, where extraction activities can infringe upon cultural rights and land sovereignty. Furthermore, the development of mining infrastructure can be a catalyst for secondary issues, including illegal logging, poaching, and social unrest, demanding responsible sourcing practices and regulatory oversight.

A THREE-PILLAR STRATEGY FOR SUPPLY CHAIN RESILIENCE AND SUSTAINABILITY

To bridge the gap between accelerating demand and sustainable supply, a decisive, three-pillar strategy must be implemented: the adoption of circular economy principles, innovative product re-design, and strengthened governance.

1. **Advancing Circularity and Decarbonising Supply**

   Current efforts to achieve circularity in CM's are insufficient, primarily due to complex material designs, inefficient collection networks, and the economic burdens of long-distance transportation for recycling. To achieve the projected 25-40% reduction in primary mining needs by 2050, domestic recycling infrastructure must be significantly expanded. Furthermore, the entire mining supply chain must be decarbonised. Mining companies must aggressively invest in renewable energy sources and deploy technologies like green hydrogen for heavy machinery to sever the link between CM extraction and substantial carbon emissions.

2. **Product Redesign and Material Substitution**

   A cornerstone of resilience is reducing mineral intensity through intelligent product redesign. This involves focusing on energy-efficient technologies and developing battery chemistries that replace difficult-to-obtain or high-impact minerals like nickel and cobalt with more abundant alternatives. Key innovations include the increasing deployment of lithium iron phosphate (LFP) and the rapid maturation of sodium-ion batteries, which offer compelling substitutes for energy storage applications where volumetric density is less critical than cost and supply resilience. Furthermore, applying circular design principles from the outset ensures that materials are managed for maximum life and optimal recovery, thereby leveraging existing material stocks and mitigating the rising costs associated with mining waste.

3. **Strengthening Governance and Policy Frameworks**

   Sound policy is the necessary mechanism to drive both sustainable demand and responsible supply. Policies must be established to incentivise environmentally and socially responsible sourcing practices, mandating the protection of local ecosystems and the rights of indigenous communities. Simultaneously, governance must address demand-side dynamics through energy efficiency policies, such as encouraging smart cities and promoting sustainable public transportation, thereby reducing the overall energy consumption and, consequently, the demand for CMs. Finally, specific incentives for recycling, such as the European Union's battery regulation, must be enacted globally to establish clear standards for material recovery, ensuring that the supply of critical minerals is increasingly fed by secondary, low-carbon sources.

CONCLUSION

The pursuit of a clean energy future is one of humanity's most critical technological undertakings, but its success hinges on confronting the material supply paradox. Achieving a truly sustainable energy transition requires simultaneous advancements in material science – such as innovating new, high-performance lithium salts – alongside radical shifts toward circular economy models and responsible supply practices. By integrating strategic product redesign, decarbonising extraction, and implementing robust governance, the industry can minimise the environmental and social impacts of critical minerals, ensuring that the foundation of the clean energy economy is both resilient and equitable for future generations.

Decarbonisation is no longer optional

Mining companies today face mounting pressure to transform their operations in line with global sustainability goals. Decarbonisation is no longer optional – it is a strategic imperative. As heavy emitters, mining firms must adopt cleaner technologies, shift toward renewable energy sources, and redesign processes to reduce greenhouse gas emissions. This transition not only mitigates climate risks but also strengthens their long-term competitiveness in a world moving rapidly toward low-carbon economies.

Equally important is the need to meet Environmental, Social, and Governance (ESG) commitments. Investors, regulators, and communities increasingly demand transparency and accountability. To achieve this, mining companies must develop robust tools to measure and track emissions across their entire supply chain. Accurate data enables them to identify hotspots, implement targeted interventions, and report progress credibly. Digital platforms, blockchain-based tracking, and advanced analytics are emerging as vital instruments for improving supply chain visibility and ensuring compliance with ESG standards.

Beyond environmental responsibility, mining companies must also prioritise social impact. Communities near mining sites often bear the brunt of environmental degradation and economic disruption. By investing in local infrastructure, education, healthcare, and sustainable livelihoods, companies can foster trust and create shared value. Genuine community engagement ensures that mining operations contribute positively to regional development rather than perpetuating inequality.

In conclusion, the path forward for mining companies lies in integrating decarbonisation strategies with strong ESG frameworks. By leveraging data-driven tools and committing to community well-being, the industry can redefine its role – not just as extractors of resources, but as partners

DECARBONISATION IMPERATIVE

Mining is one of the most carbon-intensive industries, yet it is also central to the energy transition because it supplies critical minerals such as lithium, cobalt, and copper. **The demand for action is clear: current emission reduction trajectories fall short of climate science requirements, meaning incremental improvements are insufficient.** Companies must adopt renewable energy, electrify operations, and deploy innovative technologies to reduce Scope 1, 2, and 3 emissions.

ESG COMMITMENTS AND DATA TRANSPARENCY

To meet ESG obligations, mining firms must improve **data collection and reporting across their supply chains**. Transparent emissions tracking enables accountability and builds trust with investors and regulators. Case studies of **BHP and Rio Tinto** show how integrating the Balanced Scorecard with ESG metrics has helped align operational performance with carbon reduction goals. This demonstrates that embedding sustainability into management systems is both feasible and effective.

STAKEHOLDER INVOLVEMENT

Stakeholder engagement is critical to ensuring ESG commitments translate into real-world impact. The Responsible Mining Index (RMI+) Stakeholder Engagement Dialogue (2025) revealed gaps between corporate ESG promises and community experiences in Zimbabwe and Peru. Communities often face environmental and social challenges without adequate transparency or inclusion in decision-making. Mining companies must therefore involve local stakeholders – governments, NGOs, and residents – in planning, monitoring, and benefit-sharing.

CASE STUDIES OF ACTION

- **BHP and Rio Tinto:** Both companies have integrated ESG into their strategic frameworks, using performance metrics to drive carbon reduction.
- **Accenture's Mining Report**: Highlights how investors now see mining as a potential champion of decarbonisation, given its role in supplying critical raw materials for clean energy.
- **RMI+ Dialogue (2025):** Demonstrated that community engagement at mine sites in Zimbabwe and Peru is essential to bridging the gap between corporate ESG commitments and lived experiences.

COMMUNITY BENEFITS

Beyond emissions, mining companies must **deliver tangible benefits to local communities**. This includes investing in infrastructure, education, and healthcare, while ensuring fair distribution of economic gains. Such actions strengthen the "social license to operate" and reduce conflict between companies and communities.

CONCLUSION

The mining sector stands at a crossroads. **Decarbonisation and ESG are not optional – they are urgent demands from investors, regulators, and communities**. Companies must act decisively by adopting low-carbon technologies, embedding ESG into management systems, and engaging stakeholders transparently. Case studies from BHP, Rio Tinto, and RMI+ show that progress is possible, but scaling these efforts across the industry is essential to secure both environmental sustainability and social legitimacy.

MINING DECARBONISATION STRATEGIES: ESSENTIAL TECHNOLOGIES AND IMPLEMENTATION GUIDE

The Fundamental Challenge Facing Mining Operations in the Climate Era

Mining operations across the globe face an unprecedented technical challenge that extends beyond conventional operational optimisation. The industry must simultaneously increase production capacity to meet surging demand for critical metals while achieving substantial emission reductions. This complex scenario demands innovative mining decarbonisation strategies that can address both operational efficiency and environmental responsibility.

The mathematical reality is stark: current emission reduction trajectories fall significantly short of climate science requirements, creating a performance gap that demands fundamental operational transformation rather than incremental improvements.

THE DECARBONISATION GAP: MINING'S CLIMATE CHALLENGE

Current Emission Reduction Performance vs. Global Targets

Mining companies are currently achieving annual emission reductions of approximately 2%, based on analysis of major operators' scope 1 and 2 emissions between 2018 and 2021. To align with the Paris Agreement, however, reductions must reach 4.5% per year – more than double the present rate. This shortfall equates to a 40% gap against science-based targets by 2030, positioning mining among the most challenged industrial sectors in terms of decarbonisation.

Emission reduction requirements span multiple operational scopes:

Scope 1: Direct emissions from mining equipment, processing facilities, and on-site energy generation

Scope 2: Indirect emissions from purchased electricity and thermal energy

Scope 3: Value chain emissions, including supplier activities, transportation, and downstream processing.

THE CRITICAL METALS PARADOX

The industry faces a fundamental contradiction: expanding production to meet surging demand while simultaneously reducing emissions. Global copper demand is projected to rise by 70% by 2040, driven by renewable energy infrastructure and electric vehicle manufacturing. Lithium demand is expected to increase even more dramatically – potentially by 4,000% – as battery storage deployment accelerates.

Meeting this demand requires significant capacity expansion, including new mines, processing facilities, and transportation infrastructure. Each expansion introduces new emission sources, even as operators are under pressure to reduce their absolute carbon footprint. Compounding this challenge is the geological reality of declining ore grades. As high-grade deposits become scarce, extraction and processing shift toward lower-grade ores, which demand greater energy inputs per unit of refined metal. This dynamic intensifies the paradox: more production requires more energy, yet climate commitments demand less carbon.

High-efficiency photovoltaic arrays

Advanced inverter systems for grid synchronisation

Monitoring and drone inspection

Modern Battery energy storage system with wind turbines

TECHNOLOGIES DRIVING MINING DECARBONISATION

Renewable Energy Integration

Solar microgrids represent the most immediately viable decarbonisation solution for remote mining operations. Compared to diesel generators, these systems typically deliver 30-50% reductions in energy costs while providing reliable power for processing equipment and worker facilities. Modern solar installations incorporate:

- High-efficiency photovoltaic arrays designed for harsh environments
- Advanced inverter systems for grid synchronisation and power quality management
- Predictive maintenance protocols using satellite monitoring and drone inspection
- Hybrid configurations combining solar, wind, and battery storage for continuous operation

Wind power offers substantial potential but requires more complex technical integration. Large-scale installations demand careful geological assessment to ensure foundation stability and safe clearances from mining equipment.

ELECTRIFICATION OF HEAVY EQUIPMENT

Electrification of mining fleets marks another transformative pathway. Battery-powered haul trucks, in particular, eliminate diesel combustion emissions while delivering performance comparable to conventional trucks in suitable operating environments. This shift represents one of the most significant technological advances in mining decarbonisation, directly addressing scope 1 emissions from heavy machinery.

MINING DECARBONISATION: INFRASTRUCTURE, SUPPLY CHAINS, AND ECONOMIC DRIVERS

Infrastructure Requirements for Fleet Electrification

The electrification of mining fleets demands far more than the procurement of battery-powered vehicles. Mining sites must develop the supporting infrastructure necessary to sustain large-scale electrification. This includes the installation of high-capacity charging stations, upgrades to electrical distribution systems, and the implementation of smart grid management

Equipment Type	Battery Capacity	Operating Range	Payload Capacity	Charging Time
100-ton haul truck	1,200-1,500 kWh	6-8 hours	100 tonnes	2-3 hours
200-ton haul truck	2,400-3,000 kWh	5-7 hours	200 tonnes	3-4 hours
Underground LHD	200-400 kWh	4-6 hours	15-20 tonnes	1-2 hours

technologies. These measures are essential to accommodate simultaneous charging demands without overloading local power generation capacity. In this way, electrification becomes not only a technological shift but also a systemic transformation of mining site infrastructure.

PROCESS OPTIMISATION AND ENERGY EFFICIENCY

Beyond electrification, mining operations are increasingly turning to process optimisation strategies to reduce energy consumption. Artificial intelligence (AI) applications in energy management have emerged as a powerful tool in this regard. Machine learning algorithms can analyse equipment performance data, enabling operators to optimise power consumption patterns while maintaining production targets.

Another critical avenue for efficiency gains lies in heat recovery systems. Modern technologies capture waste thermal energy from smelting and refining operations, repurposing it for power generation or process heating. Depending on the scale and configuration of operations, these systems can reduce overall energy consumption by 10-25%. Together, AI-driven optimisation and heat recovery represent significant opportunities for mining companies to improve efficiency while advancing decarbonisation goals.

ADDRESSING SCOPE 3 EMISSIONS

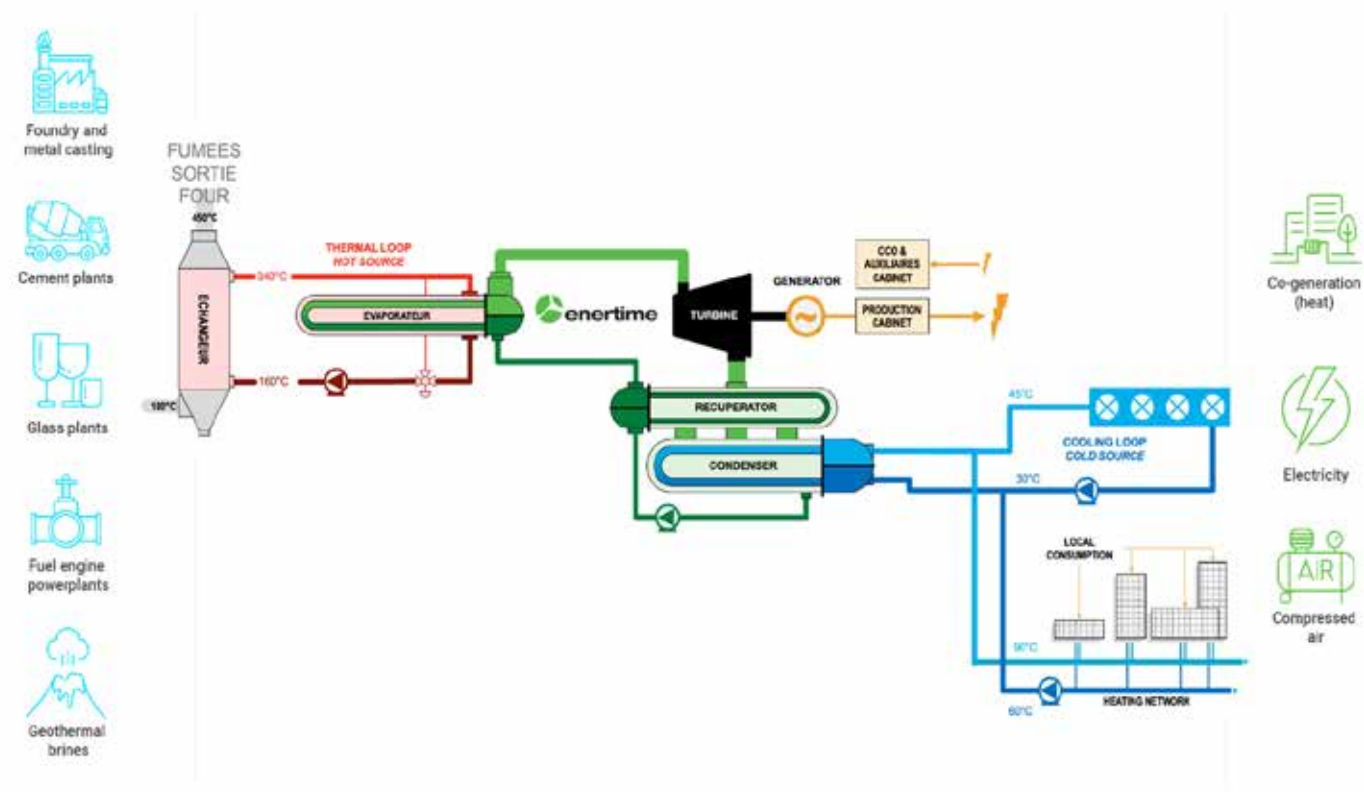
While scope 1 and 2 emissions are central to operational decarbonisation, scope 3 emissions often account for 70-80% of a mining company's total carbon footprint. Addressing these indirect emissions requires a comprehensive approach to supply chain decarbonisation.

Leading mining operators have begun implementing supplier carbon accounting frameworks that include mandatory emission reporting, carbon footprint assessments for logistics services, and sourcing preferences for low-carbon raw materials. Collaborative target-setting across supplier networks further strengthens these initiatives. Transportation logistics, in particular, represent the most controllable component of scope 3 emissions. By partnering with logistics providers, mining companies can optimise shipping routes, adopt fuel-efficient modes of transport, and transition to alternative fuel vehicles.

Downstream integration is equally important. Customer partnership programs allow mining

Fleet optimisation: Green mining technologies often deliver long-term operational savings through reduced energy consumption and improved efficiency.

Technology Category	Initial Investment	Operational Savings	Payback Period	Risk Factors
Solar Microgrids	$2-5M per MW	30-50% energy costs	5-8 years	Weather dependency
Electric Fleet	$3-8M per vehicle	20-40% fuel costs	8-12 years	Battery replacement
Process Optimisation	$0.5-2M per system	10-25% energy costs	3-5 years	Implementation complexity
Energy Storage	$1-3M per MWh	15-30% grid costs	6-10 years	Technology evolution



Waste heat recovery

companies to track product lifecycle emissions and collaborate on efficiency improvements. These initiatives focus on optimising processing techniques, enhancing recycling rates, and developing lower-carbon end-use applications. Circular economy principles – such as design for disassembly, improved recovery from waste streams, and the integration of secondary materials – further reduce reliance on primary mining, thereby lowering emissions across the value chain.

ECONOMIC DRIVERS OF MINING DECARBONISATION

The transition to low-carbon mining is not solely an environmental imperative; it is also shaped by economic considerations. Capital investment requirements vary significantly depending on the technology category and scale of implementation. As such, mining companies must undertake rigorous cost-benefit analyses to evaluate the financial sustainability of decarbonisation strategies.

Green mining technologies often deliver long-term operational savings through reduced energy consumption and improved efficiency. However, the upfront costs can be substantial, requiring careful planning and prioritisation. Ultimately, the economic drivers behind mining decarbonisation underscore the need for balanced strategies that align environmental objectives with financial viability.

Infrastructure requirements for fleet electrification extend beyond vehicle procurement. Mining sites must install high-capacity charging stations, upgrade electrical distribution systems, and implement smart grid management to handle simultaneous charging demands without overloading local power generation capacity.

PROCESS OPTIMISATION AND ENERGY EFFICIENCY

Artificial intelligence applications in energy management deliver measurable efficiency improvements across mining operations. The integration of AI in mining operations enables machine learning algorithms to analyse equipment performance data, optimising power consumption patterns while maintaining production targets.

Heat recovery from smelting and refining operations presents substantial energy savings opportunities. Modern heat recovery systems capture waste thermal energy for power generation or process heating, achieving **10-25% reduction in overall energy consumption** depending on operation scale and configuration.

MINING DECARBONISATION: PATHWAYS, CHALLENGES, AND FUTURE SCENARIOS

The transition to electric mining fleets represents one of the most capital-intensive aspects of decarbonisation. Vehicle acquisition costs and the development of charging infrastructure demand significant upfront investment. Yet, these expenditures are offset over time by operational savings, particularly through the elimination of diesel fuel consumption and reduced maintenance requirements. The long-term economics of electrification therefore remain compelling, even as companies grapple with the immediate financial burden.

Regulatory and market incentives further shape the

economics of mining decarbonisation. Carbon pricing mechanisms, whether through direct taxation or participation in emissions trading systems, impose tangible costs on mining operations. With current carbon prices ranging from $20 to $100 per tonne of CO_2 depending on jurisdiction, companies face strong financial motivations to invest in emission reduction strategies. At the same time, environmental, social, and governance (ESG) criteria increasingly influence access to capital markets. Institutional investors often enforce strict carbon intensity thresholds, rewarding companies that demonstrate credible decarbonisation progress with lower-cost financing, while penalising those without clear strategies through higher borrowing costs.

Regional differences in policy and technology adoption highlight the uneven pace of progress across the global mining industry. The European Union leads with stringent requirements under the Green Deal and Emissions Trading System, enabling EU-based operators to achieve annual emission reductions of 3-4%, compared to the global average of 2%. Australia benefits from abundant renewable energy resources and supportive government policies, with major mining operations integrating large-scale solar and wind installations to reduce reliance on grid electricity. In North America, preparations for carbon border adjustment mechanisms are reshaping competitive dynamics, as low-carbon domestic production gains advantages over imports with higher emission intensities.

Case studies illustrate the potential of comprehensive decarbonisation strategies. Large-scale renewable energy installations at copper and iron ore mines have achieved reductions of 40-60% in scope 2 emissions while maintaining full production capacity. Pilot programs for hydrogen-powered mining equipment also show promise, particularly in underground operations where battery-electric solutions face practical limitations. Hydrogen fuel cells deliver consistent power output and rapid refuelling, offering advantages over conventional battery systems in demanding environments.

Despite these successes, significant barriers continue to hinder faster progress. Technical and infrastructure challenges are particularly acute at remote mining sites, where grid connectivity limitations prevent access to large-scale renewable energy. Energy storage capacity remains insufficient to support continuous operations, as current battery technologies lack the duration required for energy-intensive processing equipment. Equipment reliability also poses concerns, with harsh mining environments – characterised by extreme temperatures, dust, vibration, and chemical exposure – testing the resilience of clean technologies. Financial and organisational obstacles compound these difficulties. High upfront capital requirements, often ranging from $50 million to $200 million for large-scale projects, create cash flow challenges, especially for junior operators. Uncertain return on investment timelines and the costs of replacing legacy infrastructure further complicate financing decisions.

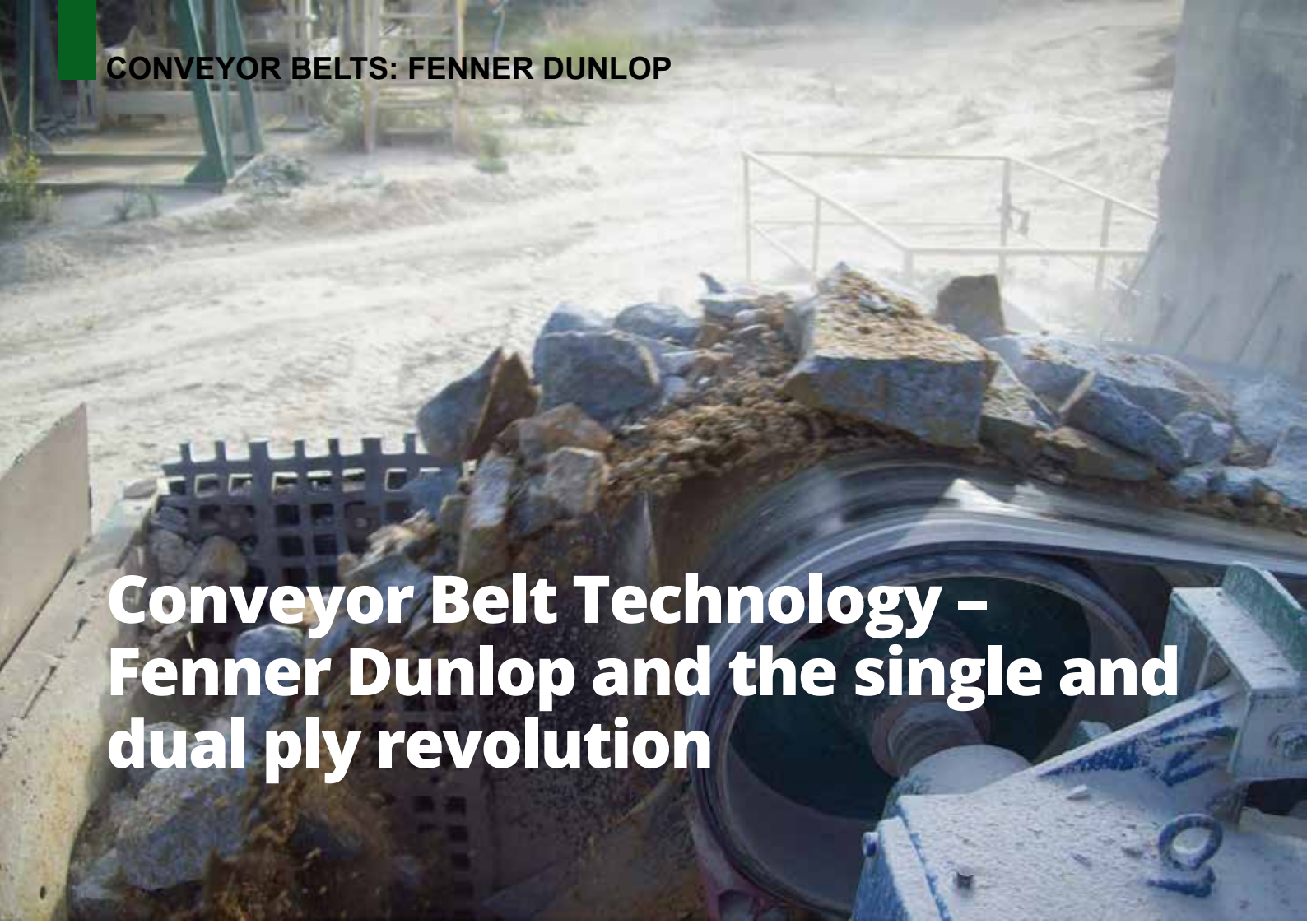
Looking ahead to 2030, technological innovation offers potential breakthroughs. Next-generation battery storage systems designed for mining applications are expected to deliver two to three times current energy density, enabling practical electrification of larger haul trucks and extended operation between charging cycles. Hydrogen fuel cells are likely to play a growing role in heavy-duty equipment, particularly where battery systems remain impractical. Carbon capture, utilisation, and storage (CCUS) technologies also present opportunities for reducing emissions from processing operations reliant on fossil fuel combustion, though commercial viability will depend on significant cost reductions.

Industry transformation scenarios suggest three possible pathways. In an accelerated scenario, comprehensive technology adoption, supportive regulation, and industry collaboration could enable annual emission reductions of 4.5%, aligning mining with Paris Agreement targets. A baseline scenario, characterised by gradual deployment and incremental policy support, may achieve reductions of 2.5-3% annually, representing progress but falling short of climate goals. In a laggard scenario, insufficient investment and regulatory barriers could limit reductions to less than 2% per year, exposing the industry to heightened climate risks and competitive disadvantages. Achieving the accelerated pathway will require coordinated action across technology providers, mining operators, financial institutions, and regulators.

Energy consumption remains the single largest source of emissions in mining, accounting for 60-70% of the total footprint. Diesel fuel use in haul trucks, excavators, and generators contributes 40-50% of scope 1 emissions, while electricity consumption in processing and refining accounts for 30-40% of scope 2 emissions. These energy-intensive processes, including crushing, grinding, and metallurgical refining, demand continuous high-power operation, complicating renewable integration efforts. To measure and manage these emissions, mining companies rely on standardised frameworks such as the Greenhouse Gas Protocol and ISO 14064. Independent verification, often costing between $50,000 and $200,000 annually, ensures credibility in ESG reporting. Increasingly, digital monitoring technologies provide real-time visibility, integrating equipment telematics and energy consumption data to optimise operations.

Investors play a pivotal role in driving decarbonisation. Institutional investors and sovereign wealth funds frequently exclude companies without credible strategies from their portfolios, while climate risk assessments in project financing demand detailed evaluation of emission reduction plans and regulatory compliance. Green bond financing has emerged as a key mechanism, with the mining sector issuing $15-20 billion since 2020 to support clean technology investments. These financial instruments provide access to lower-cost capital for companies demonstrating clear commitments to decarbonisation.

The future of mining decarbonisation is therefore shaped by a complex interplay of technological innovation, regulatory frameworks, financial incentives, and investor expectations. While uncertainties remain, companies that pursue aggressive strategies are likely to secure competitive advantages, both in regulatory compliance and market positioning. The industry's trajectory toward 2030 will depend on its ability to overcome current barriers, scale emerging technologies, and align economic imperatives with climate commitments.



Conveyor Belt Technology – Fenner Dunlop and the single and dual ply revolution

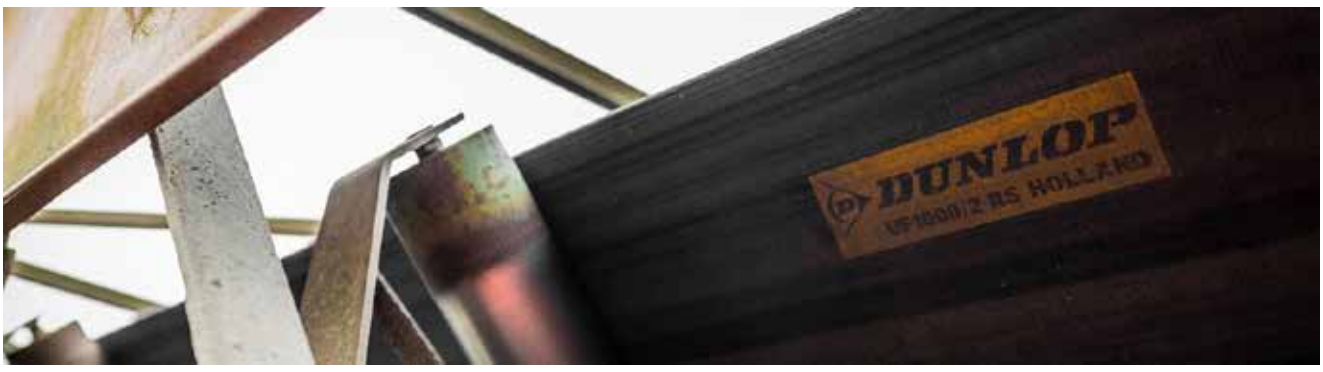
The fundamental design of rubber conveyor belts has remained largely unchanged since 1905, when mining engineer Richard Sutcliffe introduced the first belt constructed from layered cotton and rubber. Over time, the main modifications have been material-based: natural rubber has been almost entirely replaced by synthetic compounds, and the cotton layers have given way to synthetic fabric plies – typically polyester and polyamide – separated by thin rubber skim layers.

The principles of application remain consistent. Heavier loads and more abrasive materials demand belts with multiple plies and thicker outer covers, while lighter, single- or dual-ply belts are reserved for less demanding tasks. However, in recent years, Netherlands-based Fenner Dunlop Conveyor Belting, together with their sister company Fenner Dunlop North America, have challenged these long-standing conventions – ushering in what can only be described as a revolution in conveyor belt technology.

THE STORY SO FAR

More than two decades ago, the highly successful single and dual-ply UsFlex belt was introduced, pioneering the concept of replacing traditional multi-ply belts with stronger, more efficient single and dual-ply alternatives.

Around six years later, the UsFlex line was expanded with the launch of the Ultra X single-ply belt, marking the start of what became known as the X Series. This range was further strengthened by the addition of Nova X, creating a complete portfolio of belts covering tensile strengths from 250 N/mm through to 2000 N/mm.



Building on strong foundations – UsFlex has been extremely successful for Fenner Dunlop

WHY?

Before examining how this was technically achieved, it is first important to understand why the development was considered worthy of significant investment in time and resources. The driver lies in a global conveyor belt market that has become increasingly cut-throat. Over the past two decades, particularly in Europe, the market has been flooded with low-price imports from Southeast Asia, primarily China. In the pursuit of greater market share and the displacement of European competitors, performance and product longevity are often sacrificed to achieve prices that can be more than 50% lower than those offered by established manufacturers committed to quality principles.

With a long-standing brand and a globally trusted reputation for quality, the Dunlop strategy was to compete on overall cost rather than headline price by producing belts capable of withstanding the toughest demands and delivering operational lifetimes previously unheard of. The result: far fewer stoppages for repairs and a much lower frequency of replacements due to damage and wear. At the same time, the company knew it held two decisive technical advantages.

HOW

The first advantage lay in a long history of innovative technology in the development of high-performance rubber. A recent laboratory survey demonstrated that this rubber was, on average, more than 65% more resistant to abrasive wear than competing materials. In effect, the groundwork was already in place. With that strength established, the next logical focus became the synthetic fabrics used in the belt carcass. In this area, the company held a second major advantage, operating its own fabric weaving facility in the USA.

THE OPPORTUNITY

Irreparable carcass damage caused by ripping, tearing and heavy impact has long been a major issue for many operators, especially in mining and quarrying. While some consider such damage to be unavoidable, growing numbers have resorted to fitting increasingly thicker, heavier belts or using low price imported ‘sacrificial’ belts. Unfortunately for those operators, neither provides a practical, cost-effective solution.

In theory, the higher the number of inner plies then the stronger the belt. In multi-ply textile conveyor belts manufactured in accordance with ISO 14890, the declared longitudinal tensile strength is the combined result of the individual fabric plies working together in tension. For example, a belt designated as an EP 630/4 contains four layers of polyester/nylon (EP) fabric reinforcement and has a nominal overall tensile strength of 630 N/mm. Each ply has its own breaking strength, typically around 160 N/mm, and when the plies are bonded together through the rubber skim layers and form the belt’s carcass, their individual strengths effectively ‘join forces’. However, the greatest influence on the strength of a conveyor belt is actually the design and physical properties of the ply material itself.

Using their own textile R&D facilities and the years of experience of the fabrics used in their UsFlex belts, the engineers at Fenner Dunlop were able to develop a range of unique super-strength fabrics for single-ply belts (Ultra X and Nova X).

Fenner Dunlop have their own weaving facilities in North America.

The heart of the matter – individual fibres and yarns of the highest possible quality and strength.

THE HEART OF THE MATTER

The whole working principle of creating advantages from using single and dual-ply carcass belts centres on the fabric. The first priority was to ensure that the individual fibres and yarns were of the highest possible quality and strength. Next came the design of the weave pattern.

The X Series has three unique versions of fabric. Ultra X features a specially woven “crimped warp” carcass, combining crimped polyester warp yarns with strong binder and filler yarns, creating exceptional strength, stability, and impact resistance. The higher tensile strength Nova-X uses an even stronger crimped warp fabric with binder yarns to lock the carcass, providing excellent rip, tear, and impact resistance under load. For the very toughest applications there is the heavier duty UsFlex, which employs a “straight warp” carcass made of high-tenacity polyester fibres protected by polyamide weft lines.

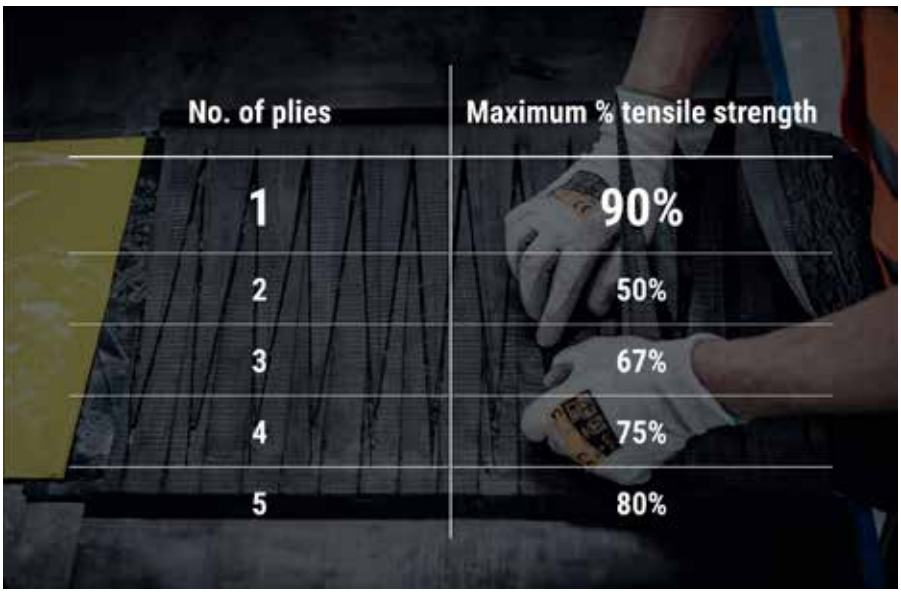
All of the fabrics consist of longitudinal strands lengthwise and heavy strands running crosswise, held in position by a strong yarn. The strands are completely straight in both directions and not interlocked as in conventional fabric, allowing the weft to float free from the warp.

This creates a shock absorber effect by dissipating impact energy over a larger area, enabling the belt to withstand the kind of punishment that would destroy a normal multi-ply belt. Arguably even more important is the ability to resist rip and tear damage.

When penetrated and being pulled through a strong, sharp, trapped object such as a rock, the unique weave design allows the strands to gather in a bundle that eventually become strong enough to stop the belt altogether or even expel the object causing the damage.

Weft strands bundle together to stop belt or expel penetrating object. *(Source: Graphically enhanced image supplied by Fenner Dunlop).*

Synthetic plies are generally more effective than steel in reducing the length of a rip. The UsFlex fabric is so robust that it is also employed as a breaker ply in steel cord belts. The outcome of this development was the creation of carcasses with longitudinal rip resistance exceeding that of multi-ply belts of equivalent tensile strength rating by more than 500%, and impact resistance up to 300% greater than conventional belting.



Much stronger – a finger splice retains up to 90% of the tensile strength.

GREATER SPLICE EFFICIENCY

The concept that a single- or dual-ply belt can deliver the tensile strength required to replace a multi-ply construction, while also offering superior resilience and durability, may seem counterintuitive. The explanation lies in the exceptional strength of the fabrics combined with far greater splice efficiency. While a conventional step splice can be applied to dual-ply UsFlex belts, single-ply designs require the use of a finger splice. The major advantage of finger splicing is its ability to retain up to 90% of the belt's original tensile strength.

By contrast, a four-ply step splice achieves a maximum of only 75% tensile strength, and a three-ply step splice retains no more than 67%. To illustrate, a 630/4 designated belt incorporates four layers of fabric reinforcement, each with a breaking strength of approximately 160 N/mm. When one ply is lost during step splicing, the effective tensile strength falls below 500 N/mm, highlighting the significant efficiency gap compared to finger-spliced single-ply constructions.

Finger splice joints are stronger and more durable

This is why the X Series single-ply belts deliver tensile strengths and safety factors fully comparable to conventional belting constructed with three or four layers. For instance, an Ultra X3 single-ply belt is capable of handling loads of up to 56 tonnes. An important additional benefit of this design is that finger splice joints are significantly stronger and more durable, reducing the frequency of repairs and re-splicing.

Another key advantage is the enhanced flexibility of single and dual-ply belts, making them particularly well suited for mobile conveyors, which often operate with small-diameter pulleys. Continuous flexing in such systems places considerable dynamic stress on both the carcass and splice joints, typically restricting the strength of belts that can be installed. The X Series design overcomes this limitation, ensuring reliable performance under demanding conditions.

WEAPONISING THE COST FACTOR.

Although a wide range of conventional, premium-quality multi-ply and steel cord belting continues to be produced, the X Series single-ply and dual-ply designs are regarded as the future of industrial conveying. By effectively reversing the traditional economic argument – and demonstrating to a price-driven market that overall cost matters far more than headline price – conveyor belt technology can now be seen as having truly entered the 21st century.

AUTHOR

Leslie David

Leslie David has specialised in conveyor belting for over 20 years and is one of the most published authors on conveyor belt technology in the world.

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.

These machines are not just cleaner – they are 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 Mining & Quarry World evaluates the roles of Hybrid and Battery-Electric machines within the mining industry.

WHAT IS 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 percent, 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.

Optimising results and ROI from conveyor safety training

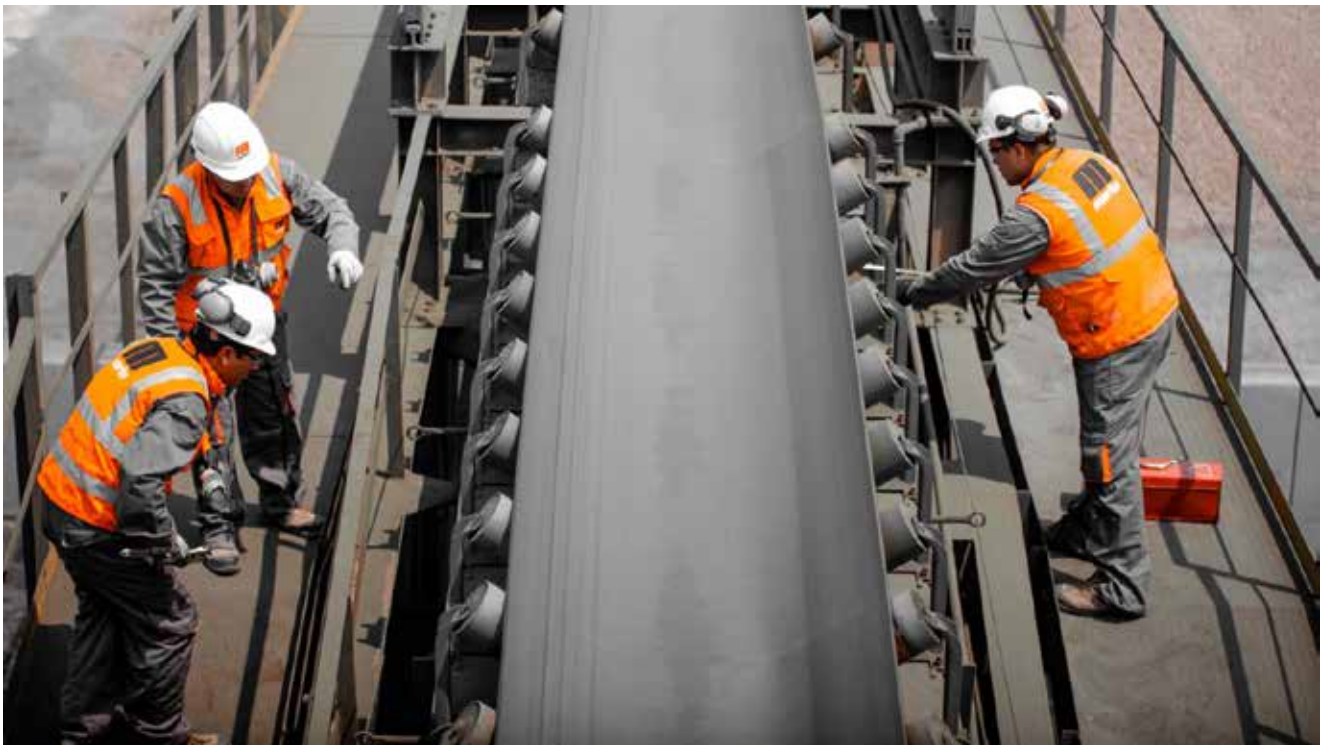
The hours spent training production and maintenance teams can lead to variable results. They might just tick the boxes without providing a return on investment. Or they can enhance safety, foster team building, and develop a deep understanding of the equipment that boosts efficiency and uptime.

Training should be robust and encourage problem-solving using modern methods and standards. Companies that prioritise safety experience fewer safety incidents, less regulatory oversight, and higher productivity and profits.

When it comes to conveyor belts, a one-day training session can serve as a refresher, but it is recommended that staff complete a comprehensive course lasting at least 2 days. Conveyors are as complex as they are crucial to operations, and training should include a mix of classroom and hands-on learning, followed by a pilot program to encourage team building and gauge results.

THE PROBLEM

A commitment to safety starts at the top with corporate culture. A "production-at-all-costs" approach means safety



Conveyor maintenance can be dangerous even when LOTO and other safety measures are in place.

concerns are always present. Bad habits and injuries often stem from three things:

- Lack of funding.
- An understaffed maintenance department.
- A “run-till-broke” mentality.

Good safety habits require training and the patience for extra steps. Cutting corners and labelling it “efficiency” can lead to serious injuries, low morale, downtime, and lost production.

BASIC TRAINING

Everyone who operates, cleans, or maintains conveyors should be trained on the hazards of bulk material handling. Basic training helps staff identify problems and resolve them safely. Appropriate safety training emphasises a basic understanding of conveyor design and operation, as well as the Lock-Out Tag-Out (LOTO) procedures required for working on and around the system.

ADVANCED TRAINING

Over time, production demands cause the conveyor belt speed and capacity to reach beyond the original design specifications. Systems are incrementally modified to minimise problems associated with the demands. Advanced conveyor design training for engineers and mechanics is critical for diagnosis and the development of updated solutions. No two conveyors are identical, so adhering to standard design methods allows a technician to make adjustments that another can recognise and understand.

DAY ONE

A walk down “problem belts” before the training helps the instructor focus on site-specific problems and the management’s expectations. The first day starts in the classroom with the class reviewing typical problems, discussing challenges, and the best practices of safely addressing them. The class identifies a couple of problem conveyors and splits into small teams. Each team examines the same problem and brainstorms solutions.

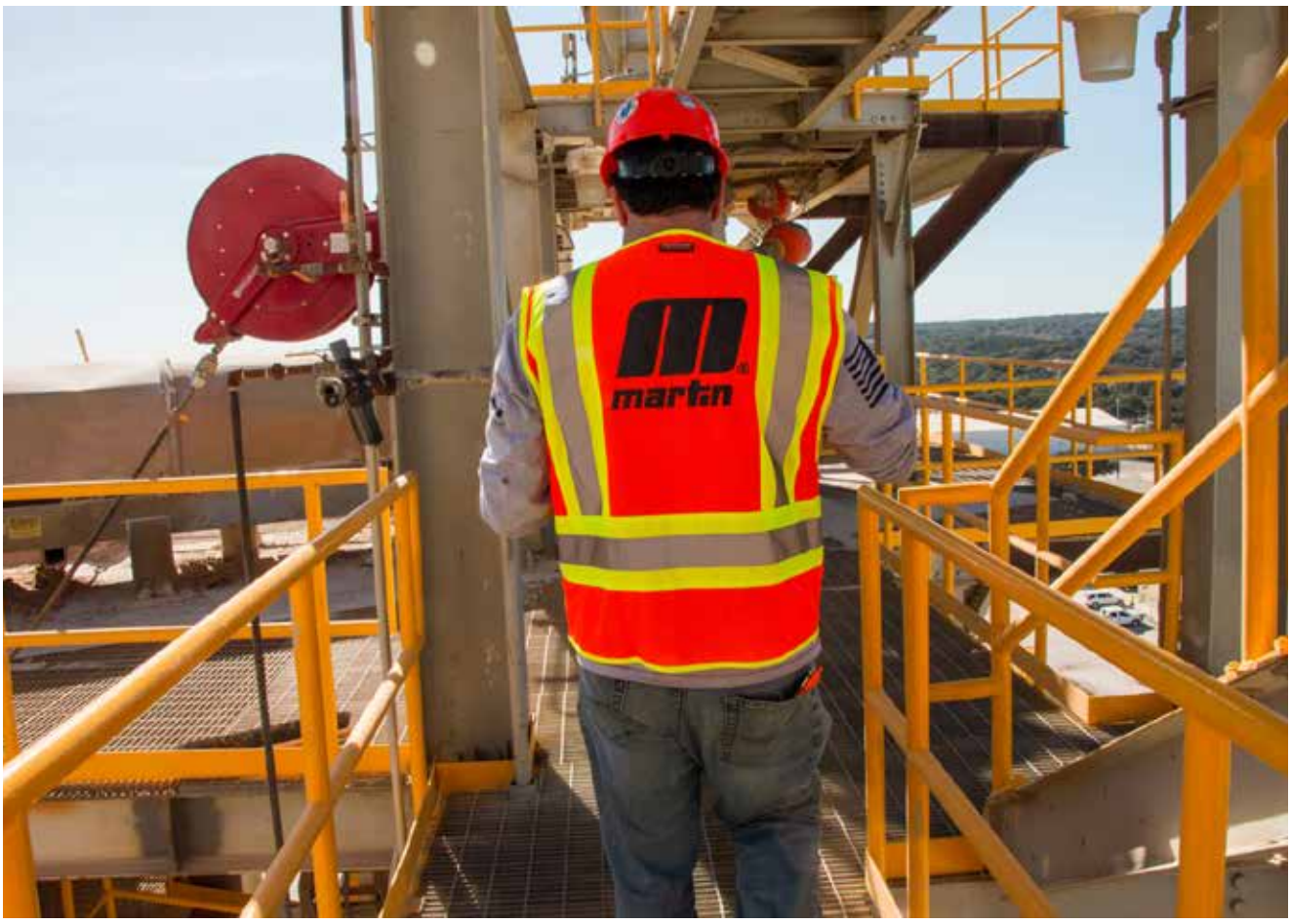
A conveyor system with safety engineered into the design maximises efficiency and productivity.

Advanced conveyor training highlights the relationship between equipment, efficiency, and safety.

DAY TWO

The class reviews and discusses root causes, solutions, and procedures. Once the teams reach an agreement, they prepare a short presentation using the knowledge they gained. The presentations may also include an estimate of the cost of the proposed solutions.

Management is then invited to listen to the team presentations, ask questions, and show a commitment to safety and communication. By making the presentations,



Third-party inspection ensures the integrity of pilot results.

trainees display knowledge and support for the solutions. It is critical at this step that the manager(s) who attend the presentations have the authority to act on the proposals and are willing to commit to a pilot program to demonstrate that theoretical results can be translated into reality.

PILOT PROGRAM

One or more conveyors from the presentation are selected for a pilot program. Usually, the results of the pilot program are immediately noticeable. A lapse in maintenance affects the pilot results, so extend the test period to the next scheduled shutdown, with periodic inspections and adjustments made by the equipment manufacturer.

CONCLUSION

It is incumbent upon management to take safety and maintenance training as seriously as the staff, listen to employees' concerns, and fix the problem correctly the first time. As research has shown, companies that prioritise safety, training, and updating equipment enjoy fewer safety incidents, less regulatory oversight, higher productivity and greater long-term profits.

The online Martin® Foundations™ Learning Center draws on the collective knowledge and expertise gathered over 80+ years of solving bulk-handling challenges. Aimed at apprentice technicians and experienced engineers alike, the non-commercial information is offered at no charge and is accessible by computer, tablet, or smartphone. An extension of the Foundations training curriculum, the Learning Center uses a mix of text, photos, videos, webinars, online events, and live experts available to answer questions.

AURTHOR

R. Todd Swinderman
President Emeritus / Martin Engineering

R. Todd Swinderman earned his B.S. from the University of Illinois, joining Martin Engineering's Conveyor Products division in 1979 and subsequently serving as V.P. and General Manager, President, CEO and Chief Technology Officer. Todd has authored dozens of articles and papers, presenting at conferences and customer facilities around the world and holding more than 140 active patents. He served as President of the Conveyor Equipment Manufacturers' Association (CEMA) was the editor of CEMA's 6th and 7th editions of Belt Conveyors for Bulk Materials, The Design Guide for Belt Conveyors. Todd is active on several CEMA committees including Chair of the Bulk Safety Committee and is a member of the ASME B20 committee on conveyor safety which set U.S. conveyor safety standards. Swinderman retired from Martin Engineering to establish his own engineering firm, currently serving the company as an independent consultant.

Chinese uranium miner to help build Namibia's second desalination plant

Swakop Uranium, a subsidiary of state-owned China General Nuclear Power Group, has signed a joint venture deal with Namibia's water utility, NamWater, to construct the country's second desalination plant close to Swakopmund.

The new plant, only the second of its type in one of Africa's driest countries, will help bolster water supplies to the country's largest uranium mine, Husab, and support communities in the Erongo region of Namibia, close to the Atlantic Ocean.

In a statement recently,the joint venture partners said negotiations had ended successfully and the project's implementation phase would now start. Swakop Uranium holds a 70% stake and NamWater the remainder.

"The next steps include the registration of the Erongo Sunam Desalination Project Joint Venture Company, the detailed engineering, environmental assessments, financing arrangements and construction planning," according to the statement.

The new 20-million cubic-meter facility, on the cards since 1998, is expected to provide stable and cost-effective water supply to Swakop Uranium's Husab mine, as well as neighbouring mines and communities.

Husab mine is the world's largest open-pit uranium mine and the largest consumer of water in the Erongo region and the second-largest single consumer of water in the country after the City of Windhoek, officials said.

NamWater's spokesperson, Lot Ndamanomhata, declined to disclose how much the project would cost, although local newspapers reported an estimated N$3-billion cost.

Why metal prices will continue to rise in 2026

Stabilised global markets hold the key to continued minerals and metals price growth in 2026, according to a new report by BMI.

The report said prices will likely edge higher as trade tensions and tariff uncertainties subside, with robust demand expected for critical mineral sectors linked to the transition to net zero and Western nations' supply chain security.

BMI forecasts gold prices will average higher in 2026 compared to 2025, though it expects prices to ease later in the year as monetary-easing policies lose momentum, particularly as the US Fed eventually stops cutting rates.

Industrial policy will continue to play a key role as critical minerals deals begin to materialise, the report said, with most activity centred around the EU and US.

"Governments will push a twin-track strategy: scaling domestic capacity while locking in overseas supply via investment and strategic partnerships," the report said.

The analysis also anticipates pushback from China's government as Western nations attempt to diversify supply chains away from reliance on China.

"Mainland China will double down on industrial policy to cement its dominance across critical mineral value chains. Measures include accelerated upstream exploration, targeted capacity expansion in critical minerals, and greener manufacturing practices," the report said.

"China will deepen partnerships with resource-rich economies via clearer outbound-investment frameworks, as recent tariffs and rare earth export curbs show protectionist leverage remains central."

The surge in M&A activity seen during 2025 is also expected to continue as companies consolidate assets, operations and resources around critical minerals, including copper, lithium and rare earths.

"Large-scale capex projects still remain in focus, yet risk-averse developments are coming to the forefront," the report said.

"Rio Tinto's completion of the acquisition of Arcadium Lithium in March 2025, alongside Pilbara Minerals' earlier acquisition of Latin Resources in February 2025, further reinforces ongoing industry consolidation within the critical minerals space."

Frontier and emerging markets have also been earmarked for increased investment activity.

"While resource nationalism has been a key concern for a while, we believe governments and local populations in regions including Africa now have more awareness and bargaining power over their mineral resources," the report said.

"This will enable more progress to be made on mineral beneficiation compared to previous years, with global mining investors having little choice but to comply with mineral policy changes in these jurisdictions."

Metals and mining projects are also expected to benefit from partnerships with tech, automotive and aerospace companies in 2026 – including through offtake agreements – as manufacturers look to get ahead of supply bottlenecks in key growth sectors such as AI, robotics and defence.

Dust hazards and control strategies in underground mining

Underground mining environments present a wide spectrum of hazards to workers, ranging from structural collapse and flooding to explosions. Among these risks, airborne dust remains one of the most persistent and difficult to manage. Generated in large volumes by drilling, blasting, and material handling operations, dust poses serious health and safety concerns. Over the past decades, numerous techniques have been developed to mitigate dust exposure, and more recently, novel approaches employing advanced technologies have been proposed. Despite these efforts, dust control remains a formidable challenge. ***Gordon Barratt of Mining & Quarry World details some of the preventative measures to ensure mine worker safety on site.***

Most conventional dust suppression methods achieve reductions in the range of 25-50% of respirable dust. While this represents a meaningful improvement, it is often insufficient to meet regulatory compliance standards. As a result, mine operators typically employ multiple control strategies simultaneously, sometimes without clear evidence of which measures are most effective. This uncertainty is compounded by inherent variability: dust sampling carries an estimated 25% margin of error, while day-to-day dust generation in the same mine can fluctuate by as much as 50%. Nevertheless, industry consensus has identified three principal categories of dust control – ventilation, water application, and dust collection –msupplemented by preventative strategies that minimise material disruption and breakage.

VENTILATION IN MINE SHAFTS

Ventilation remains the cornerstone of dust control in underground mines. Properly designed systems serve two critical functions: dilution and displacement. Dilution involves introducing clean air to reduce the concentration of dust particles, while displacement ensures that dust is carried downwind, away from workers. The effectiveness of dilution is directly proportional to airflow volume, yet increasing airflow is both technically demanding and financially costly. Air velocities approaching 1 km per minute within ductwork or shafts present particular challenges, as further dilution becomes increasingly difficult to achieve.

Displacement ventilation, by contrast, focuses on confining dust at its source and directing it away from personnel. This technique is commonly applied at continuous miner faces and tunnel boring machines operating under exhaust ventilation. Another example is the enclosure of dust-generating transfer points, such as conveyor belt

junctions, where contaminated air is extracted directly from the enclosure. However, displacement ventilation is not without obstacles. When workers operate within three to five meters of a dust source, air velocities of up to 50 m/minute may be required to maintain effective downwind displacement. In many underground settings, such airflow volumes are simply unattainable.

To address these limitations, two engineering strategies are employed. First, reducing the cross-sectional area of the air course between the dust source and workers increases air velocity, thereby improving confinement. Second, minimising turbulence at the dust source reduces eddy currents that can push dust upwind toward workers. By lowering turbulence, less airflow is required to contain dust clouds effectively. These measures enhance the reliability of displacement ventilation, making it the most effective dust control strategy currently available.

WATER-BASED SUPPRESSION

Water application is one of the most widely used dust suppression techniques in mining. By wetting surfaces and airborne particles, water reduces dust liberation and enhances particle agglomeration, causing dust to settle more quickly. Water sprays are commonly deployed at drilling rigs, conveyor transfer points, and loading operations. In addition, high-pressure misting systems can generate fine droplets that capture respirable dust particles, binding them into larger aggregates that fall out of the air.

The effectiveness of water-based suppression depends on several factors, including droplet size, spray pressure, and the chemical composition of the water. Additives such as surfactants or wetting agents are often introduced to improve water penetration into hydrophobic coal dust or fine mineral particles. However, water suppression has limitations. Excessive water application can lead to operational inefficiencies, including equipment corrosion, reduced visibility, and increased slurry management requirements. Furthermore, in arid or water-scarce regions, the availability of sufficient water supplies poses a significant constraint. Despite these challenges, water-based suppression remains a practical and cost-effective method, particularly when integrated with ventilation and dust collection systems.

DUST COLLECTION SYSTEMS

Dust collection systems represent a more targeted approach to dust control, focusing on capturing and removing dust at its source. These systems typically employ mechanical or electrostatic collectors, filters, and cyclones to separate dust particles from the air. Local exhaust ventilation (LEV) systems are a common example, designed to extract contaminated air directly from enclosed or semi-enclosed dust sources such as crushers, transfer points, or drilling operations.

Baghouse filters and cartridge collectors are widely used in underground mines, offering high efficiency in capturing fine particulate matter. Cyclone separators, while less effective for respirable dust, provide robust performance for larger particles and are often used as pre-cleaners in multi-stage systems. Electrostatic precipitators, though less common in underground mining due to space and power constraints, can achieve high collection efficiencies in specific applications.

The success of dust collection systems depends on proper design, maintenance, and integration with other control measures. Poorly maintained filters or inadequate airflow can compromise system performance, while over-reliance on collection systems without complementary ventilation or water suppression may leave workers exposed. Nonetheless, when effectively implemented, dust collection systems provide a critical layer of protection, particularly in high-dust environments where other methods alone are insufficient.

CONCLUSION

Dust control in underground mining is a complex and evolving discipline. While water sprays and dust collection systems play important roles, ventilation – particularly displacement ventilation – remains the most effective means of safeguarding workers. The challenges of airflow management, turbulence reduction, water availability, and equipment maintenance underscore the need for continued innovation and rigorous application of engineering principles. As mining operations advance, integrating preventative strategies with proven ventilation, water-based suppression, and dust collection techniques will be essential to achieving compliance standards and protecting worker health in one of the most hazardous industrial environments.

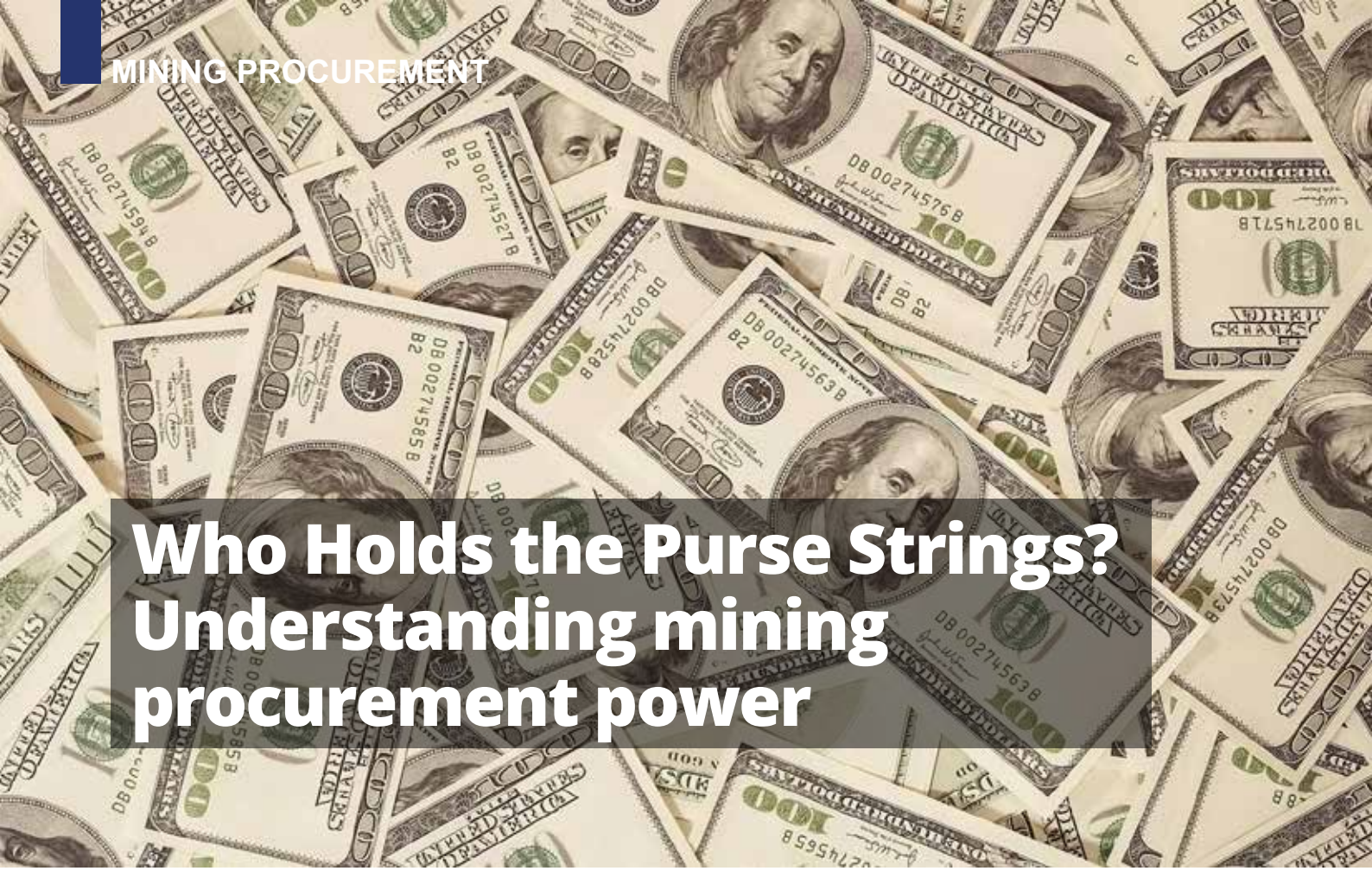
HARD-ROCK QUARRY: FOG-BASED DUST SUPPRESSION AT BARDON HILL

At Bardon Hill Quarry in the UK, one of the largest hard-rock quarries, operators implemented a dry fog suppression system to manage dust across more than 3,000 meters of conveyor transfer points.

- System design: Fine water mist was applied at conveyor head and tail transfer points, binding dust particles and preventing them from becoming airborne.
- Results: The system significantly reduced airborne dust levels in a harsh quarry environment, improving visibility and worker safety.
- Durability: The fog suppression system proved resilient under continuous heavy-duty operation, providing long-term dust control without excessive water use.

This case highlights the role of water-based suppression technologies in hard-rock mining, where conveyor transfer points are major dust sources. By targeting these areas, operators achieved effective dust reduction while minimising operational disruptions.

Conclusion: Case studies confirm that no single dust control method is sufficient. Effective strategies rely on layered approaches – ventilation, water suppression, and dust collection – adapted to the mining environment. These real-world examples show how engineering innovation and operational discipline combine to protect workers and meet compliance standards.



Who Holds the Purse Strings? Understanding mining procurement power

Trevor Barratt, Managing Director of both *Coal International* and *Mining and Quarry World*, draws on his experience working in the mines during the 1960s and 1980s to compare how equipment and services were purchased then, with the requirements of 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 scrutinize 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

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

Figure 1: Large planetary gearbox

Figure 2: Sight glass

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.

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

Figure 3: Stroboscope gearbox inspection.

Figure 4: Revealed bearing damage from a teardown inspection.

INSPETOR 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. 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.

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.

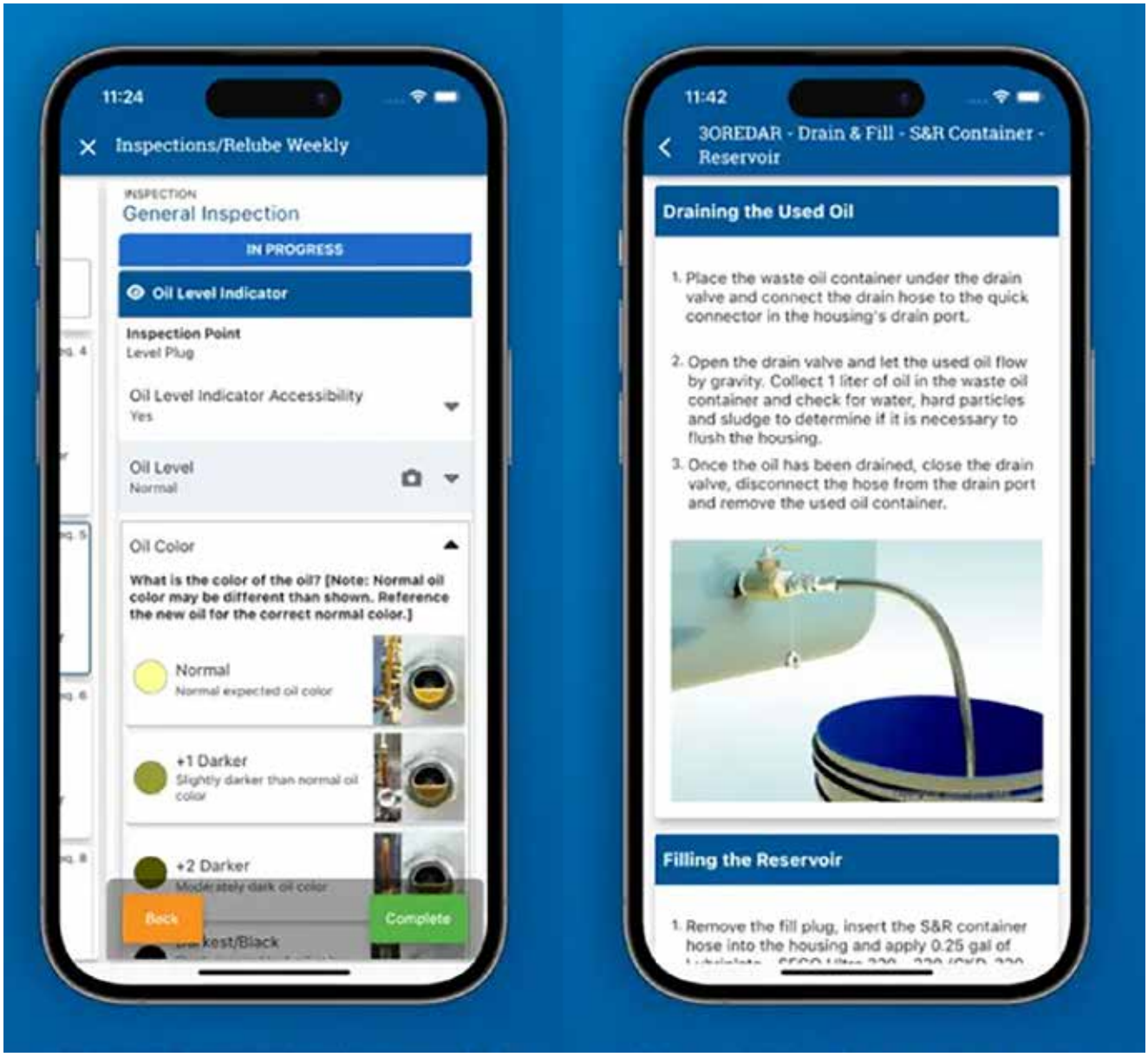


Figure 5: LubePM.

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

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.

Drilling rigs

Drilling rigs – both surface and underground – represent one of the most decisive technological pillars of modern mining. Their success is measured not only in terms of productivity and efficiency, but also in their ability to adapt to diverse geological conditions, enhance safety standards, and support sustainable resource development.

Surface drilling rigs have transformed exploration and open-pit mining by enabling precise sampling, rapid blast-hole creation, and reliable geological data collection. Their versatility across terrains and integration of advanced automation have made them indispensable for large-scale operations.

Underground drilling rigs, by contrast, have revolutionised subsurface mining. Operating in confined and hazardous environments, they provide controlled rock fragmentation, support ground stabilisation, and increasingly rely on autonomous systems to reduce human exposure. Their evolution from mechanical jumbos to intelligent, battery-electric rigs underscores their role in advancing both safety and environmental responsibility.

Together, surface and underground drilling rigs embody the mining industry's pursuit of efficiency, adaptability, and innovation. Their success lies in bridging exploration and production, enabling miners to unlock resources at depth and scale while meeting the demands of modern sustainability and safety standards.

Gordon Barratt of Mining & Quarry World takes a detailed look at these pillars of modern mining.

COMPARISON OF THE ROLE OF SURFACE AND UNDERGROUND DRILLING RIGS IN MINING

Drilling rigs are fundamental to mining operations, but their roles differ significantly depending on whether they are deployed on the surface or underground. Both types of rigs contribute to resource extraction, yet they serve distinct functions shaped by geology, mining methods, and operational environments.

SURFACE DRILLING RIGS

- Used mainly in exploration and open-pit mining.
- Provide geological samples through diamond core or reverse circulation drilling.
- Create blast holes for controlled rock fragmentation in large-scale surface operations.
- Underground Drilling Rigs
- Primarily employed in tunnelling, stope development, and ore extraction.
- Drill blast holes in confined spaces to advance drifts and stopes.
- Support ground stabilisation through rock bolting and anchoring systems.

OPERATING ENVIRONMENT

- Surface Rigs
- Operate in open, accessible areas with fewer spatial constraints.
- Must handle variable terrain and weather conditions.
- Mobility is key – truck-mounted rigs can move quickly between sites.
- Underground Rigs

Comparative Summary

Aspect	Surface Drilling Rig	Underground Drilling Rig
Main Use	Exploration, open-pit blasting	Tunnelling, stope blasting, rock support
Environment	Open terrain, variable weather	Confined, hazardous underground spaces
Design Focus	Mobility, depth penetration	Compactness, manoeuvrability, safety systems
Technology	Rotary/DTH, GPS automation	Multi-boom jumbos, remote/autonomous systems
Success Contribution	Geological data, large-scale ore recovery	Safe excavation, productivity in confined areas

- Function in restricted, hazardous environments with limited ventilation.
- Require compact, low-profile designs to manoeuvre in narrow tunnels.
- Safety systems (dust suppression, fire protection) are critical due to confined conditions.

TECHNOLOGICAL ADAPTATIONS

- Surface Rigs
- Incorporate high-capacity rotary and down-the-hole (DTH) systems for deep penetration.
- Increasingly automated with GPS alignment and digital monitoring for precision drilling.
- Underground Rigs
- Feature drilling jumbos with multiple booms for simultaneous hole drilling.
- Advanced rigs integrate automation, remote operation, and battery-electric power to reduce emissions underground.

CONTRIBUTION TO MINING SUCCESS

- Surface Rigs
- Enable resource discovery and large-scale ore extraction.
- Provide accurate geological data essential for mine planning.
- Improve efficiency in open-pit blasting operations.
- Underground Rigs
- Facilitate safe and controlled excavation of ore at depth.
- Enhance productivity in tunneling and stope development.
- Reduce human exposure to hazardous underground conditions through automation.

CONCLUSION

Surface and underground drilling rigs share the common goal of enabling efficient resource extraction, but their roles diverge sharply due to environmental and operational demands. Surface rigs excel in exploration and large-scale open-pit mining, while underground rigs are indispensable for safe, precise, and productive excavation in confined spaces. Together, they represent complementary technologies that

Sandvik

Epiroc

Atlas

Sandvik

underpin the success of the mining industry across diverse geological settings.

A detailed list of some of the most successful drilling rigs currently in use across mining operations worldwide is shown below, highlighting both surface and underground applications. These rigs are recognised for their efficiency, adaptability, and technological innovation.

SANDVIK DR416I

- Large rotary blasthole rig designed for open-pit mines.
- Drills holes up to 406 mm in diameter.
- Known for automation, fuel efficiency, and high penetration rates.

EPIROC PIT VIPER SERIES (PV-271, PV-311)

- Widely used in large-scale surface mines.
- Offers autonomous drilling capabilities and advanced GPS alignment.
- Proven success in maximising productivity and reducing operator exposure.

ATLAS COPCO ROC L8

- Versatile rig for both production drilling and exploration.
- Strong reputation for reliability in hard rock conditions.
- Compact design with high mobility across varied terrains.

SANDVIK LEOPARD DI650I

- Down-the-hole (DTH) rig optimised for high-pressure drilling.
- Advanced control systems for precision and reduced fuel consumption.
- Success in mid-size open-pit operations.

UNDERGROUND DRILLING RIGS

Underground rigs (often called jumbos) are critical for tunnelling, stope development, and rock support.

SANDVIK DD422IE

- Battery-electric jumbo drill for underground mining.
- Reduces emissions and ventilation costs.
- Automated drilling cycles improve accuracy and safety.

EPIROC BOOMER M2 & M4 SERIES

- Two- and four-boom rigs for tunnelling and development.
- Known for versatility in narrow vein and large-scale mines.
- Incorporates advanced operator cabins and digital monitoring.

SANDVIK DL421 LONGHOLE DRILL

- Specialised for longhole production drilling.
- High accuracy in ore extraction and ground support.
- Proven success in deep underground mines.

EPIROC SIMBA E7

- Longhole production rig with advanced automation.
- Capable of drilling parallel holes for efficient blasting.
- Widely adopted in mechanised underground operations.

The latest technical innovations in drilling rigs focus on automation, digital integration, sustainability, and advanced materials – transforming both surface and underground mining operations into safer, more efficient, and environmentally responsible systems.

KEY INNOVATIONS IN DRILLING RIGS

Automation & Artificial Intelligence (AI)

Autonomous drilling cycles reduce human intervention, improving safety in hazardous environments.

AI-driven optimisation adjusts drilling speed, torque, and pressure based on real-time geological feedback.

Machine learning algorithms predict equipment wear, enabling predictive maintenance and minimising downtime.

DIGITAL INTEGRATION & REAL-TIME MONITORING

IoT-enabled rigs use sensors to track vibration, torque, depth, and temperature.

Cloud-based analytics provide predictive insights, reducing exploration costs by up to 30%.

Operators can remotely monitor and control rigs, ensuring precision and reducing human exposure underground.

SUSTAINABILITY & ENERGY EFFICIENCY

Battery-electric rigs eliminate diesel emissions, lowering ventilation costs in underground mines.

Eco-friendly hydraulic systems reduce fluid consumption and environmental risks.
Energy-efficient designs cut power usage while maintaining high penetration rates.

ADVANCED MATERIALS & MANUFACTURING

Use of lightweight, durable alloys improves rig portability and lifespan.

Additive manufacturing (3D printing) enables custom drill components tailored to specific geological conditions.

ENHANCED SAFETY SYSTEMS

Automated shut-off and fire suppression systems integrated into rigs.

Ergonomic operator cabins with filtration protect against dust and hazardous gases.

Remote operation reduces direct human exposure in confined underground spaces.

TECHNOLOGICAL ADVANCEMENTS DRIVING SUCCESS

Modern rigs incorporate diesel, hydraulic, and increasingly electric power systems, which improve efficiency and reduce environmental impact. Key innovations include:

- Automated control panels for real-time monitoring of drilling parameters such as depth, pressure, and rotation speed.
- Safety mechanisms like emergency shut-offs and ergonomic designs, reducing operator risk.
- Down-the-hole (DTH) drilling technology, which combines rotary and hammer action for deeper penetration in hard rock formations.

These advancements have significantly increased Overall Mining Equipment Effectiveness (OMEE), measured through availability, utilisation, and productivity indices.

SUCCESS FACTORS

The success of surface drilling rigs in mining can be attributed to several interrelated factors:

CHALLENGES AND FUTURE OUTLOOK

Despite their success, surface drilling rigs face challenges such as high capital costs, wear from abrasive rock, and the need for skilled operators. However, the industry is moving toward automation, electrification, and digital integration, which promise even greater efficiency and sustainability. Electric-powered rigs, for example, are gaining traction due to their reduced carbon footprint.

CONCLUSION

Surface drilling rigs have transformed mining by combining precision, efficiency, and safety. Their success is evident in their widespread use across exploration and production, their adaptability to geological conditions, and their integration of advanced technologies. As mining continues to evolve, surface drilling rigs will remain central to unlocking resources while balancing productivity with environmental responsibility.

ELECTRIC/HYBRID VS. DIESEL DRILLING RIGS IN MINING

Drilling rigs are fundamental to mining operations, enabling blast hole creation, exploration, and ore body access. For decades, diesel-powered rigs have dominated the industry, valued for their robustness and ability to deliver high torque in demanding environments. However, the mining sector is undergoing a technological transformation driven by environmental, social, and governance (ESG) pressures, rising fuel costs, and the global push toward decarbonisation. Electric and hybrid drilling rigs have emerged as viable alternatives, offering efficiency gains and reduced environmental impact. This article provides a comparative analysis of electric/hybrid and diesel-powered rigs, focusing on performance, environmental considerations, economic implications, and strategic adoption.

TECHNICAL AND OPERATIONAL PERFORMANCE

Diesel rigs are renowned for their high-power density and reliability. They are capable of operating in remote and harsh environments where fuel logistics are straightforward, and they remain the preferred choice for deep drilling and heavy-duty applications. However, diesel engines generate significant noise and vibration, which can affect operator comfort and safety.

Electric rigs, by contrast, deliver consistent power output with fewer mechanical losses, improving drilling precision. Hybrid rigs, which combine diesel engines with battery energy storage systems, optimise load profiles and reduce fuel consumption. Field trials have demonstrated fuel savings of up to 26 percent, highlighting their potential to improve operational efficiency. Electric and hybrid rigs also offer smoother operation and enhanced responsiveness, particularly under variable load conditions.

ENVIRONMENTAL IMPACT

The environmental footprint of diesel rigs is considerable. They emit carbon dioxide, nitrogen oxides, and particulate matter, which necessitate extensive underground ventilation systems. These emissions contribute significantly to the mining industry's carbon footprint and pose challenges under increasingly stringent regulatory frameworks.

Electric rigs eliminate on-site emissions, improving underground air quality and reducing ventilation requirements. Hybrid rigs, while not entirely emission-free, substantially reduce diesel consumption and associated pollutants. Both technologies also lower noise pollution, enhancing worker safety and community relations. As mining companies pursue decarbonisation strategies, electric and hybrid rigs align more closely with sustainability goals.

ECONOMIC CONSIDERATIONS

From a financial perspective, diesel rigs generally require lower upfront investment compared to electric or hybrid alternatives. However, they incur high operating costs due to volatile fuel prices and frequent maintenance of mechanical components.

Electric and hybrid rigs involve higher capital expenditure, primarily due to advanced battery systems and electrical infrastructure requirements. Nevertheless, they offer reduced operating costs through lower energy consumption, regenerative braking, and fewer moving parts requiring maintenance. Over time, these savings, combined with ESG compliance benefits, improve return on investment. Hybrid rigs, in particular, provide a transitional solution by delivering immediate fuel savings without necessitating full electrification.

STRATEGIC IMPLICATIONS

Diesel rigs remain advantageous in regions where electrical infrastructure is limited and fuel logistics are simpler. Their established role ensures continued relevance in certain mining contexts. Hybrid rigs represent a practical bridge technology, enabling operators to reduce emissions and fuel use while maintaining operational flexibility. Electric rigs, however, signal the long-term direction of the industry, particularly in underground mines where ventilation costs are high and decarbonisation targets are strict.

The adoption of electric and hybrid rigs reflects a broader industry trend toward sustainability and efficiency. As technological advancements reduce costs and improve performance, these rigs are expected to gain increasing market share, gradually displacing diesel as the dominant technology.

CONCLUSION

The comparison between electric/hybrid and diesel-powered drilling rigs highlights a fundamental trade-off between established reliability and innovative sustainability. Diesel rigs continue to dominate due to their robustness and lower capital cost, but electric and hybrid rigs are increasingly attractive for their efficiency, environmental benefits, and alignment with modern mining strategies. Hybrid rigs provide a transitional pathway, while electric rigs represent the future of drilling technology in a decarbonising mining industry.

One of the clearest examples is Fortescue Metals in Australia, which has begun replacing diesel rigs with autonomous electric drill rigs, achieving major reductions in fuel use and emissions.

FORTESCUE METALS – ELECTRIC DRILL RIG DEPLOYMENT

Fortescue Metals Group (FMG), one of the world's largest iron ore producers, has committed to achieving "real zero" emissions by 2030. As part of this strategy, the company signed a $350 million deal in 2025 to replace more than 50 diesel-powered drill rigs with autonomous electric rigs supplied by Epiroc.

Results Achieved

- Fuel Savings: The electric fleet is expected to cut approximately 35 million litres of diesel consumption annually, a significant reduction in operating costs.
- Emissions Reduction: This transition will avoid over 90,000 tonnes of CO_2 emissions per year, directly supporting Fortescue's decarbonisation targets.
- Operational Efficiency: The rigs are autonomous and operated remotely from Fortescue's Integrated Operations Centre in Perth, improving safety and reducing the need for on-site personnel.
- Scalability: The deployment marks Australia's first Pit Viper 271 E electric drill in operation, setting a precedent for large-scale adoption of electric rigs in open-cut mining.

COMPARATIVE ADVANTAGE OVER DIESEL

- Diesel rigs at Fortescue previously required extensive fu el logistics and generated high emissions, particularly problematic in large-scale open-pit operations.
- Electric rigs not only eliminate on-site emissions but also reduce ventilation requirements in underground contexts, while hybrid systems in other trials have shown up to 26% reductions in fuel use.

STRATEGIC IMPLICATIONS

Fortescue's adoption demonstrates that electric rigs can deliver both environmental and economic benefits at scale. By cutting fuel costs and emissions simultaneously, they provide a compelling alternative to diesel rigs, particularly for companies under pressure to meet ESG commitments. Hybrid rigs remain a transitional option, but Fortescue's case shows that full electrification is already viable in large mining operations.

In summary: Fortescue Metals' replacement of diesel rigs with electric Epiroc Pit Viper 271 E drills has delivered measurable improvements in fuel efficiency, emissions reduction, and operational safety, making it one of the most prominent real-world examples of electric rigs outperforming diesel in mining.

Epiroc is launching the new generation PowerROC T45

Epiroc is launching a new and improved PowerROC T45. The new generation surface drill rig offers increased fuel efficiency and high availability. It is a welcome addition to the PowerROC family.

"We are eager to get this rig out to our customers around the world. The PowerROC T45 MKII is the perfect choice for construction sites and aggregate, cement and limestone quarries,
says Sr. Product Manager Masanori Kogushi.

The new generation PowerROC T45 is equipped with an Epiroc developed control system, which helps decrease fuel consumption. This is due to the auto engine speed control, which enables automatic optimisation of the engine RPM for all operations.

"The new generation PowerROC T45 offers up to 40 % lower fuel burn compared to the previous generation",
says **Masanori Kogushi**.

To assist with easy operation, the PowerROC T45 MKII includes an intuitive 12 -inch display that presents all the necessary data, monitors running status and offers the operator additional assistance. Two one-touch lever controls make rod changing and drilling both simple and quick. The system is easy to learn and use.

The PowerROC T45 MKII has many similarities to the PowerROC T35 MKII, which was released last year. Like the other rigs in the PowerROC family, the PowerROC T45 MKII features a modular and straightforward design, which keeps servicing simple.

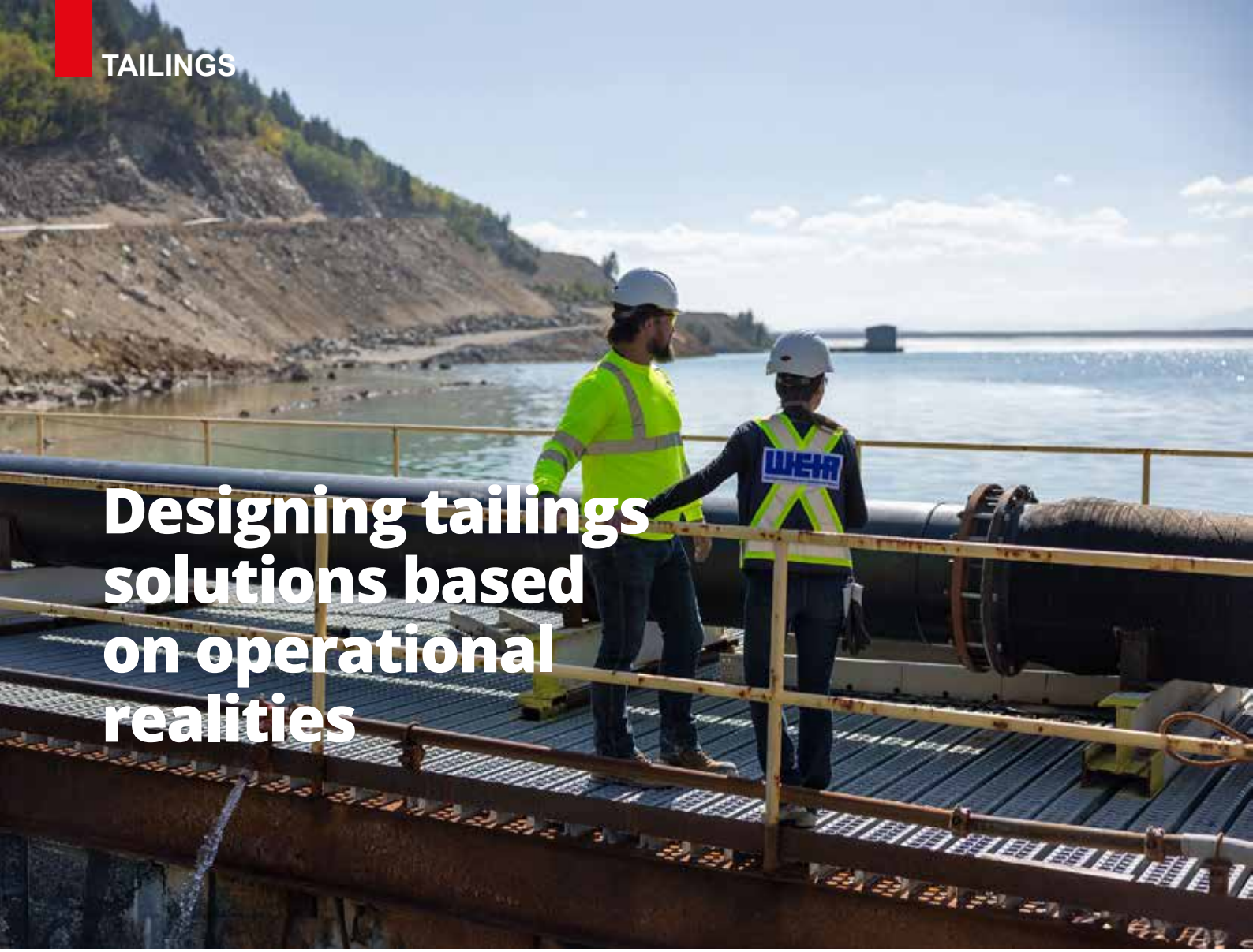
"Compared to the PowerROC T35 MKII, the PowerROC T45 MKII surface drill rig offers a big hole range, which is something many of our customers want. This PowerROC T45 MKII launch is there-fore a natural step forward in our offering within the PowerROC family",
says **Masanori Kogushi.**

The PowerROC T45 MKII has been field-tested with positive results during the last couple of months.

"We have fine-tuned the rig for maximum performance and have achieved all our major targets",
says **Masanori Kogushi**.

The new generation PowerROC T45 comes with two different engine alternatives – Tier 3/Stage IIIA and Tier 4 Final/Stage 5.

The PowerROC T45 MKII will be available for order from December 3 2025.



Designing tailings solutions based on operational realities

The trend towards greater throughputs at concentrators means that the quantity of tailings being produced is increasing. Operators can build bigger pipelines and pumping stations to manage this, but, in many instances, this will only exacerbate existing logistical challenges and oversight requirements.

Tailings dams are rising, which means operators need to make decisions regarding what to do about their diminishing capacity. Depending on the site, there will inevitably be constraints within which these decisions have to be made (i.e. regulatory requirements, space constraints, etc).

These decisions also inevitably involve challenges around oversight; for instance, there are important geotechnical and environmental considerations that must be taken into account.

It is possible, in theory, to go on building larger pumping systems, but, at some point, this becomes unmanageable and uneconomic. There is a ceiling on the economies of scale, and, in some operations, it might be more efficient to have two smaller pumping systems, rather than one big pumping system.

DESIGNING SYSTEMS ACCORDING TO OPERATIONAL SCENARIOS

If there is just a single pumping system and there are reliability issues that require the system to be shutdown, then production stops. But if an operation has multiple smaller systems and there are reliability issues with one system – or even when scheduled maintenance needs to be performed – it is still going to have some pumping capacity, albeit reduced, which means there will be less downtime.

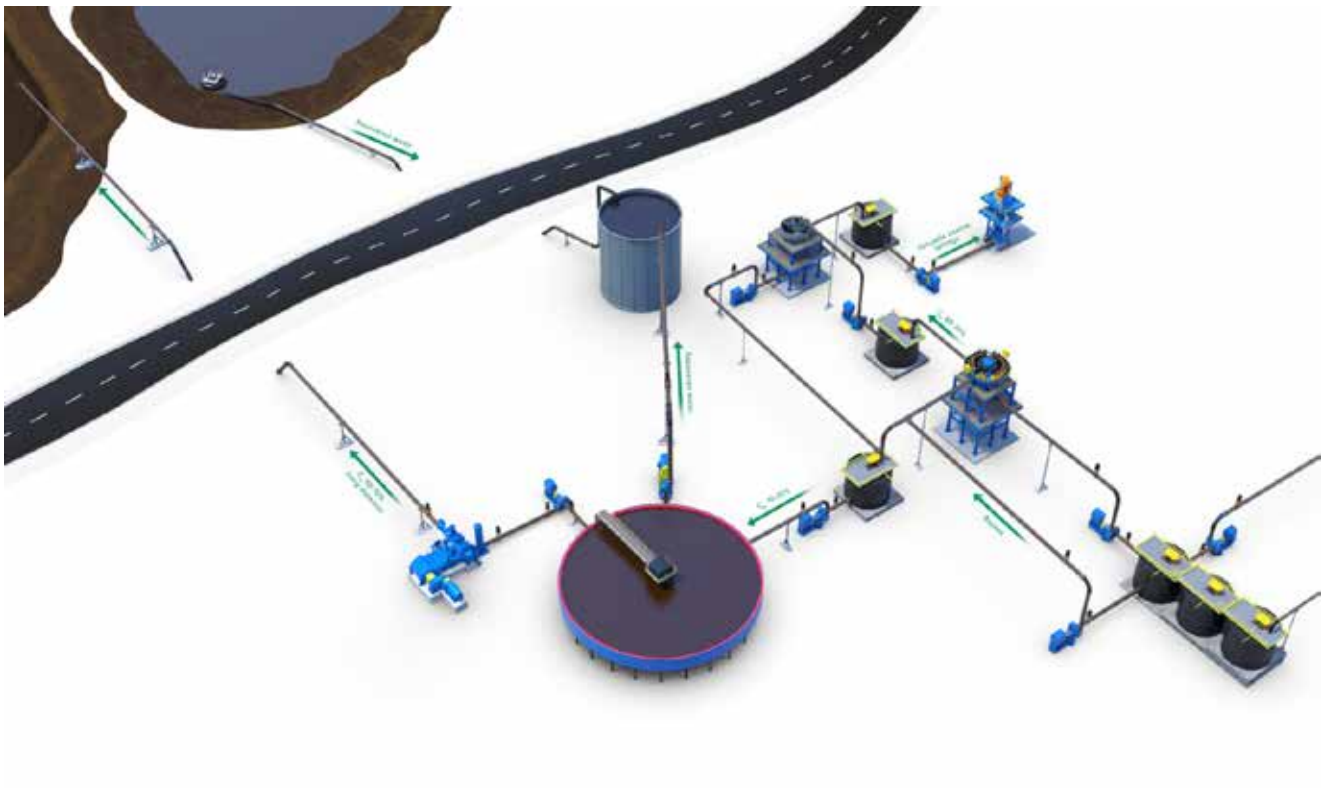
This then provides operators with greater flexibility. For instance, if a system is sized for one big flow and the pipeline needs to operate at between, say, 70-100% capacity to maintain velocity, it is not difficult to envisage a situation in which it might have to run its thickeners empty. This is obviously inefficient and energy intensive.

When designing these systems, it is crucial that the operational scenarios guide the design decisions.

FLOWSHEET-BASED APPROACH

Weir is developing tailings flowsheets. This means that it is taking a more holistic approach; rather than focusing solely on managing the flow as one big volume, it is looking at separating out the different size fractions, which then allows operators to manage them in different ways. This is about designing systems that provide greater operational flexibility.

The operator can apply cycloning or screening technology to dewater the tailings, which can remove the coarser fractions. This has benefits in terms of reducing the load



Weir's TerraflowingTM dewatering technology provides optimal balance between energy consumption and water recovery.

on the thickener, while also allowing them to reduce the size of their pipeline.

Another solution that some miners are thinking about and starting to implement is using coarse particle flotation (CPF) technology to increase their throughput. If there is an existing Semi-Autogenous Ball Mill Crusher (SABC) circuit, introducing CPF reduces the load on the comminution circuit because it reduces the amount of material that needs to be finely ground.

This allows operators to run the plant at the same or improved (if it can capture valuable metals that might have been lost in conventional flotation at coarse grind size) recovery, but at a higher throughput, while also producing a coarser tailings stream.

The coarse tailings produced by CPF are particularly valuable for tailings storage facility (TSF) construction. Free-draining sands – defined by a fines content of less than 15–18% passing seventy-five µm – can be used to build stable embankments and reduce water retention. Hydrocyclones are commonly used to separate these sands from finer material.

This approach aligns with modern tailings strategies that emphasise safety, sustainability, and a reduced footprint.

ASSESSING PROJECT FEASIBILITY

When designing and developing any solution there are always going to be trade-offs that need to be considered and that is no different for CPF.

It does represent significant capital investment, and, in brownfield projects, it must fit within the existing footprint. So, these things always need to be assessed on a case-by-case basis.

CPF also requires additional water, which can be recovered, but that needs to be investigated during the feasibility stage. Similarly, there are additional energy requirements, so all these factors – and more – need to be weighed against the increased throughput.

However, that said, while these projects must be evaluated individually, CPF generally provides operational benefits and is likely to see broader implementation in the future.

Weir collaborates with its customers, consultants and EPCs to encourage them to adopt new technologies. While innovation is a popular topic of discussion these days, mining remains a risk-averse sector, so it is important that OEMs like Weir are working hard to encourage adoption by validating more innovative technologies and solutions and demonstrating that they can deliver quantifiable benefits.

DRIVING INNOVATIVE, SUSTAINABLE SOLUTIONS

Weir engages in some very exciting projects that have the potential to make some significant progress in reducing tailings' environmental burden.

For instance, in South America, Weir is working on various studies with partners to investigate how to get a fines-free product that is suitable for alternative TSF disposal scenarios.

In Australia, it is doing test work with its TerraflowingTM dewatering technology to explore alternative approaches to thickening as a way of recovering more water. It is an approach that Weir thinks might provide more flexible flowsheets, particularly for those operating in arid regions.

TRANSFORMING TAILINGS PIPELINES

Weir is also now offering operators pipeline solutions that have proven particularly well-suited to tailings applications,

Formed flanges and face-to-face sealing of Arterra™ UHMWPE pipelines ensure smoother connections, reducing turbulence and wear.

where long distances and abrasive slurries create the most demanding conditions.

Weir's advanced pipeline solution Arterra™ is an ultra-high molecular weight polyethylene (UHMWPE) material proven in medical implants and marine applications. It is extending pipeline life significantly in some of Australia's harshest environments.

The key to the performance of Arterra™ UHMWPE pipelines lies in the molecular structure of UHMWPE itself. Arterra™ pipes have a molecular weight of 3.5×106 grams per mole (g/mol), compared to HDPE with a molecular weight of 0.5x106g/mol. With a surface roughness of just 0.2 microns, the material is exceptionally smooth, almost hydrophobic in its resistance to adhesion.

The surface smoothness of this material offers friction benefits that translate directly to reduced power requirements and extended service life, resulting in significant yearly savings at sites that have made the switch.

For instance, a South Australian iron ore operation was using conventional high-density polyethylene (HDPE) pipelines, which were wearing through in 3-4 weeks.

It had some slack flow portions of the pipeline. Because of the steep slope, the material was moving faster than it was being pumped – 12m per second, which is incredibly fast for pipeline operations.

When particles are pushed at that velocity through a pipe filled with high-density solids, the wear is relentless.

The site's initial response – replacing failed sections every 4-6 weeks – was costly and operationally disruptive. After switching to Arterra™ UHMWPE pipeline, the same sections now last 16-18 months – that is a 16-fold improvement in service life.

BUILDING A MORE RESILIENT MINING INDUSTRY

Weir is not just responding to changes in the mining industry – it is actively shaping them. Through its commitment to innovative engineering, Weir is enabling a new era of sustainable and efficient mineral processing and tailings management.

By investing in research and development, Weir is helping mining operations around the world reduce energy use, improve tailings management, and extend the life of critical infrastructure.

AUTHOR

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Weir, Global Tailings Process Director

NEXT Intelligent Solutions

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