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Mining technology for a sustainable future

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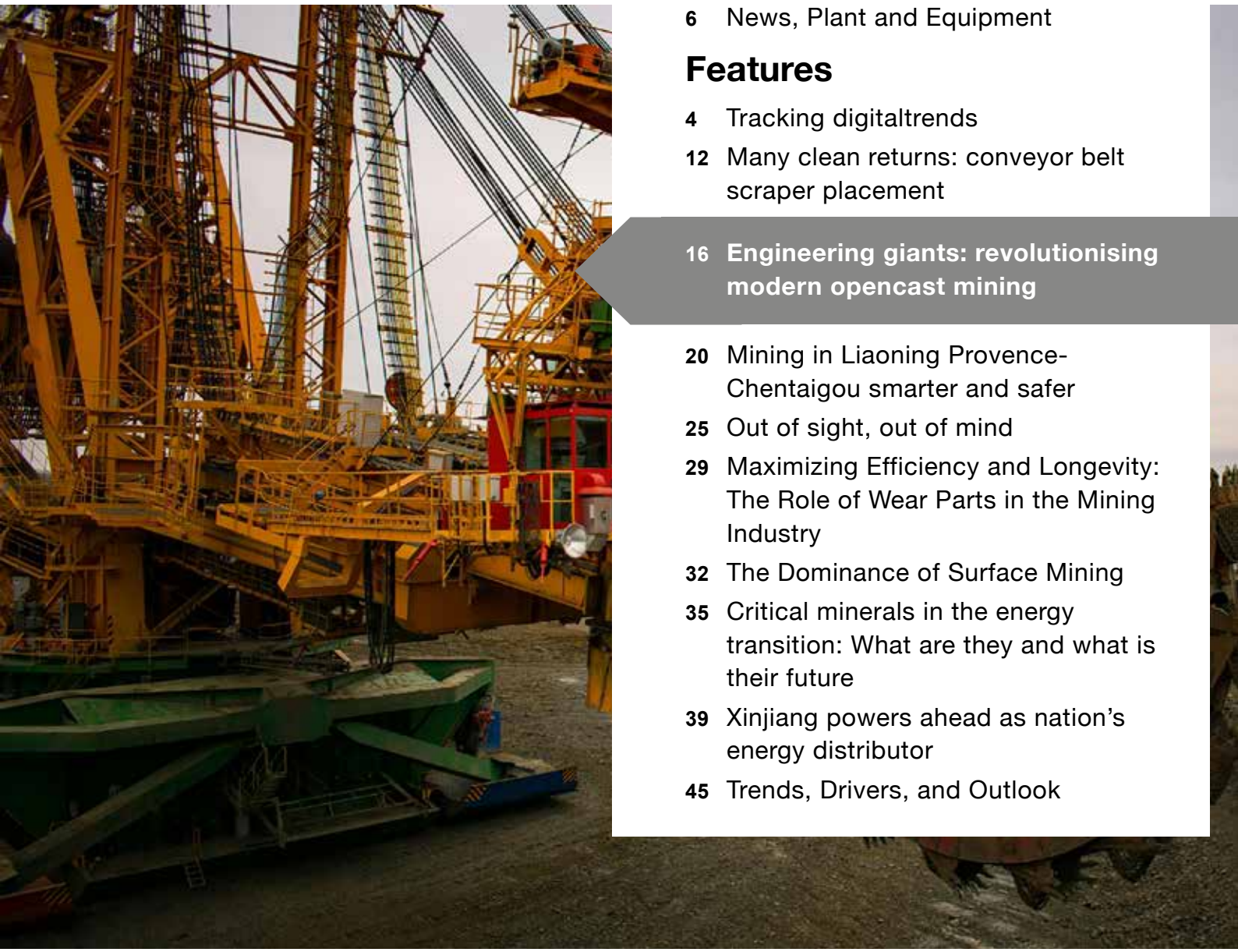
CONTENTS



6 News, Plant and Equipment

Features

4 Tracking digitaltrends

12 Many clean returns: conveyor belt scraper placement

16 **Engineering giants: revolutionising modern opencast mining**

20 Mining in Liaoning Provence-Chentaigou smarter and safer

25 Out of sight, out of mind

29 Maximizing Efficiency and Longevity: The Role of Wear Parts in the Mining Industry

32 The Dominance of Surface Mining

35 Critical minerals in the energy transition: What are they and what is their future

39 Xinjiang powers ahead as nation's energy distributor

45 Trends, Drivers, and Outlook

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Tracking digital trends

For the last seventeen year, Deloitte has been publishing *Tracking the Trends*, which analyses the most significant challenges facing the mining industry and provides insights on how mining and metals companies are tackling them. Over the last decade, the importance and centrality of digital technologies – first as something that was emerging, now as something more established but often under-utilised – has become a fixture of the report.

Tracking Trends 2025 is more bullish than ever before about the need and benefits of adopting digital technologies: 'Increasingly, companies are looking to smart operations as a solution to manage complex priorities and demands. Injecting advanced technologies such as artificial intelligence (AI), digital twins, and predictive analytics into mines offers the potential to make them more cost-effective and resilient while helping to generate measurable gains in efficiency, safety, and sustainability performance, which could prove important in leading the future race for investment and talent,' the report stated.

Indeed, some of the most pressing challenges facing the industry – attracting capital and a skills shortage – are driving more rapid adoption. At the same time, many of the operational challenges are becoming more complex.

'Historically, the mining industry has been distrustful of data and has relied heavily on humans to make decisions. However, today, the problems that mines need to solve are so complex and with so many variables that it's hard for humans to make good decisions, let alone optimal ones, in a reasonable time frame,' Herman Lombard, partner, Technology & Transformation, Deloitte Canada, explained.

'The systems and data are now becoming robust enough to solve a lot of that complexity much faster and better than humans. It's time to start trusting the data driven insights and that will likely unlock new, more cost- and resource-effective business models,' he said.

Just how significant a change in thinking and operating this shouldn't be understated. There are valid macroeconomic reasons why the mining sector has been reluctant to adopt emerging technologies, but many of these technologies are now established and the macroeconomic equation is changing. Nonetheless, implementing the required technological changes requires a top-down vision, according to Eamonn Treacy, partner, Technology & Transformation, Deloitte Canada.

'This…requires transformational leadership. Until mining companies have a senior person – that is, a chief data officer – and a team in charge of enterprise data, there may not be a single source of the truth or analytics that can serve across business functions. It's important that those individuals understand the opportunities and

limitations of current technology, as well as the true needs, differentiators, levers, and opportunities to value, not just from an industry perspective but also for the organisation and its portfolio of assets,' he said.

Mining companies recognise this and are appointing skilled leaders accordingly. For instance, in December 2023, McEwen Mining appointed Google's former Chief Evangelist Nicolas Darveau-Garneau to its board.

DIGITAL AS CONTINUATION, NOT DISRUPTION

As an OEM and digital solutions provider to the mining industry, one of the challenges Weir faces is working with customers who are in different stages of their digital journey. At the same time, different miners want different things from digital technologies. These are typically informed by the same challenges and operational constraints that miners have long sought to overcome: increased throughput, improved efficiency and lower energy consumption just to name a few.

In other words, digital solutions should be seen as a continuation – albeit in a less manual and analogue form – of what miners have always done. And just as there isn't a one-size-fits all approach to improving process efficiency or streamlining maintenance requirements, digital solutions are more effective when they're modular, customisable and easy to integrate to the site's specific needs.

No one serves as many mines as Weir, so it's close to its customers, working alongside them every day, which means that it understands their operational challenges and has an existing service network to support them. And its digital solutions are an extension of this.

Weir takes a customer-centric approach; first it understands its customer's pain points, then it outlines a plan for how it can harness digital technologies to improve equipment and process efficiency, their servicing requirements or whatever other objectives they're struggling to meet. Each customer is different – in both the challenges they want digital technologies to help them overcome, as well as their digital maturity – and Weir develops and delivers solutions accordingly.

CUSTOMER-CENTRIC APPROACH

Weir takes a structured approach to the digital solutions offered to its customers. There are three packages available as part of its NEXT Intelligent Solutions, each of which deliver various customer benefits, starting with condition and performance monitoring at one end of the spectrum and AI-powered process optimisation at the other.

Firstly, the Insight package provides real-time condition, performance and maintenance monitoring. Then there's the Uptime package, which builds on and extends the capabilities of the Insight package and provides predictive and preventative monitoring solutions – for instance, wear detection and failure prediction. And finally, the Production package harnesses AI-driven technology to optimise the overlaying process and maximise efficiency from equipment to entire process circuits.

In terms of the outcomes, this is driven by the customer's needs and requirements and the Production package allows them to really focus on fine tuning the production process performance to achieve their goals or KPIs, whether that be increased throughput, stabilised P80, reduced energy consumption, etc.

SUSTAINABILITY

Deloitte's *Tracking the Trends* 2005 report is explicit about the relationship between ESG (Environmental, Social, and Governance) performance and adopting new technologies, particularly GenAI: 'For business leaders, the challenge isn't

if or when to adopt these technologies – their deployment is inevitable – instead, the focus should be on how. Strategising the deployment of AI to help ensure that it's used effectively to achieve the organisation's productivity, financial, and sustainability goals could prove an important priority over the next 12 to 24 months,' the report stated.

One way AI can be deployed is in process optimisation and it can provide an alternative to large, capital-intensive investments in additional or supplementary equipment by typically boosting the production from the operating plant with 5-10%.

An important part of our Production package is the AI-based Intelligent Assistant, which offers extensive advice on production from a strategic level – from production planning to optimal operating parameters. This is a tool that complements and supports staff at all levels, providing them with unrivalled insights and ensuring alignment between operational processes, equipment conditions and desired outcomes.

Take, as a case in point, Weir's NEXT Intelligent Assistant for Mill Circuit. The operator will receive AI driven recommendations to ensure the process stays on target by compensating for any upstream process disturbances such as changes to ore feed characteristics.

The Intelligent Assistant will alert the operator when there are relevant drifts from the expected operational parameters so that proactive actions can be taken. It also provides alerts if there's unexpected equipment failure or unanticipated process behaviour.

The Intelligent Assistant can also provide capabilities to inspect the running equipment models which will enable what-if-scenarios allowing process engineers and metallurgists to simulate operational conditions before applying them to production.

More broadly, AI powered process optimisation is essential to optimise energy consumption and maximise recovery to reach ESG targets; to produce more end product to improve overall production and, ultimately, enable the transition to a low carbon economy

SAFETY

Safety is obviously another issue of paramount importance in mining operations. Processing plants are, after all, potentially dangerous environments and digital tools are being used to reduce risk.

'By utilising the capabilities of GenAI tools, tasks can also be augmented and enhanced to speed up safe working and positive outcomes,' Deloitte's report stated.

'For example, mine maintenance teams can already use GenAI-enabled virtual field assistants as reference tools. This provides quick access to parts catalogues, manuals, and other technical information, as well as to aid troubleshooting and avoid safety pitfalls.'

Weir is also utilising its NEXT Intelligent Solutions to improve training and provide maintenance personnel with a detailed understanding of equipment; the maintenance crew can then identify potential risks before going on-site and, in a training setting, provide less experienced personnel with a comprehensive overview of how certain procedures should be executed safely.

Moreover, there are autonomous solutions that enable the removal of maintenance personnel from the line of fire and, instead, allow them to perform the work without direct human intervention. For instance, Weir has a solution for its WARMAN® slurry pumps, which is an automated throatbush adjustment.

CHANGING OPERATING ENVIRONMENTS

While Weir insists that digital technologies simply enable miners to do what they've always done, albeit more efficiently, it does concede that there are changing operational challenges that non-digital interventions are struggling to contend with. Most notably, declining ore grades. The way the mining industry has typically dealt with this is to simply increase production; however, this is no longer viable for both economic and environmental reasons.

Instead, there is increasingly a focus on more efficient process. This takes many forms – processing less non-valuable material, using less energy, dry processing and generating less tailings, just to name a few – and digital technologies will likely play an increasingly crucial role in this.

'Looking ahead, GenAI could be used to help solve complex problems in several different ways. For example, models could be used to…design and optimise flowsheets to solve complex mineral processing challenges,' according to Deloitte's report.

Indeed, solving these complex challenges has been at the heart of the design philosophy on which Weir has developed – and continues to develop – its NEXT Intelligent Solutions.

OEMs are often at the forefront of innovation and, as an end-to-end full flowsheet supplier, companies like Weir are in a unique position when it comes to harnessing digital technologies because these can be integrated into engineering, equipment, processes and the services it provides to its customers.

AUTHOR

Ole Knudsen
Weir, Senior Director – Digital

Patriot start drilling at Copper Top Hill in Zambia

Australian mining company Patriot Resources said that it had started drilling activities at its Copper Top Hill prospect, about 850 m northeast of the Sugarloaf copper deposit in Zambia's Central Copperbelt.

Following geological mapping and surface sampling, which confirmed visible copper mineralisation along strike of more than 800 m, Patriot recently announced a new copper discovery within the Sugarloaf licence, now named the Copper Top Hill prospect.

Assays from rock chip samples returned grades of up to 3.12% copper using a portable XRF analyser.

The company has planned a 3 000 m drilling campaign to assess the depth extent, continuity, and structural controls of the mineralised zone. The programme will also evaluate the potential geological connection between Copper Top Hill and the Sugarloaf system.

"The commencement of drilling at the Copper Top Hill prospect is a significant milestone for Patriot," said executive chairperson Hugh Warner.

"The grades and lateral extent of surface mineralisation are highly encouraging, and this drill programme will provide our first insights into the subsurface geometry and scale of this copper system. With access to established infrastructure and strong in-country support, we are well-positioned to rapidly advance our Zambian portfolio."

NextSource shifts BAF plans from Mauritius to Middle East

NextSource Materials is pivoting its battery anode facility (BAF) strategy from Mauritius to the Middle East, seeking to capitalise on faster permitting, better infrastructure, and closer proximity to electric vehicle (EV) manufacturers, the company said recently.

The battery materials developer has terminated its lease agreement and withdrawn an environmental impact application for a proposed BAF in Mauritius, ending a multi-year effort to establish a facility there. NextSource cited delays and regulatory uncertainty for the decision, which it said would reduce financial exposure and allow for quicker deployment of its processing equipment elsewhere.

"NextSource continues to progress our commitment to a sustainable and scalable supply chain for battery anode materials," said president and CEO Hanré Rossouw. "While the decision to terminate our lease in Mauritius has not come lightly, we are excited to pursue larger-scale opportunities in the Middle East, leveraging our expertise and assets to meet global demand more efficiently."

The company is now prioritising potential BAF sites in Saudi Arabia and the United Arab Emirates (UAE), regions that offer "streamlined permitting processes, robust infrastructure, and strategic proximity to global EV manufacturers," NextSource said.

The decision comes amid ongoing negotiations with potential original equipment manufacturers to secure offtake agreements. The company said feedback from product qualification trials has been positive, and the move to larger-scale BAFs supports its aim of establishing a secure and traceable supply chain for graphite anode material.

A presence in the Middle East also positions the company to benefit from favourable trade terms. The UAE currently faces a 10% reciprocal tariff when exporting to the US, in contrast to significantly higher tariffs on graphite anode materials from China.

Battery anode facilities are designed to convert graphite concentrate into coated, spheronised, and purified graphite, which are components of lithium-ion batteries used in EVs.

NextSource's primary asset, the Molo graphite mine in Madagascar, is one of the largest and highest-quality deposits globally and has begun production through Phase 1 operations.

Allied Gold heads for NYSE

Canadian miner Allied Gold is heading for the NYSE.

The listing on the NYSE represents a milestone for Allied, which believes that course will offer it access to. a broader investor audience, increased sources of potential capital, improved trading liquidity, and increased research coverage from US investment banks.

The listing is also expected to provide the opportunity for broader index inclusion.

Concurrent with the start of trading on the NYSE, the company's common shares will cease trading on the OTCQX market.

Allied operates three producing assets and development projects in Côte d'Ivoire, Mali, and Ethiopia.

Artemis opens Canada's newest gold/silver mine in BC's Cariboo region

Vancouver-based Artemis Gold has officially opened the Blackwater mine in central British Columbia, marking the launch of Canada's newest gold and silver operation and one of the biggest resource developments in the Cariboo region in more than a decade.

The open pit mine, located 110 km southwest of Vanderhoof, is expected to produce between 190 000 oz and 230 000 oz of gold in the 2025 financial year. Its opening follows a rapid 22-month construction period and three months of commissioning, culminating in commercial production earlier this month.

British Columbia Premier David Eby and provincial Minister of Mining and Critical Minerals Jagrup Brar joined Indigenous leaders and other stakeholders for an opening ceremony at the mine site Friday.

"Blackwater mine is an example of what can be achieved through collaboration with First Nations and the protection of vital lands and waters," Eby said. "It creates hundreds of family-supporting jobs and builds prosperity here and across the country."

The mine currently employs more than 400 people, with 25% identifying as Indigenous and 80% from within British Columbia. Artemis has invested in building the project with sustainability in mind, powering operations with hydroelectricity and installing an all-electric processing plant to reduce carbon emissions. The mine also plans to integrate zero-emission ore and waste haulage options by 2030.

"Today marks the official opening of Blackwater mine after an industry leading 22 months of construction and three months of commissioning," Artemis Gold chairperson and CEO Steven Dean said. "What we have achieved together is a model for the sustainable and responsible development of mines in first world jurisdictions, like Canada."

Blackwater mine holds measured and indicated resources of 11.7-million ounces of gold and 122.4-million ounces of silver. The mine is being developed in three phases. Construction of the first phase was completed this year, and a decision on the second phase, which could add 800 construction jobs and 170 operational positions, is expected later in 2025.

According to an economic impact study by KPMG, the project is projected to contribute C$13.2-billion to the provincial economy over its life, including C$2.3-billion in provincial and C$1.5-billion in federal tax revenues. With higher metal prices since the study was completed in 2020, actual contributions may be even greater.

"Blackwater mine is a great example of what we want to see more of in BC – a project that creates good jobs, supports local and Indigenous communities and takes crucial steps to minimize the impact on the environment," Brar said.

Artemis says that more than C$1-billion has been spent building the mine to date, including C$700-million within British Columbia and over C$300-million with local and Indigenous businesses.

The project was developed in partnership with six First Nations, including the Lhoosk'uz Dené and Ulkatcho First Nations, with whom Artemis co-developed environmental management plans addressing caribou, fish habitat, wetlands, and other conservation measures.

"Lhooskuz Dené Nation is pleased to be part of this opening ceremony in our traditional territory," said acting Chief June Baptiste. "The development of the Blackwater project will provide long term employment for our members and economic opportunities for Nation."

Chief Charlie Williams of the Ulkatcho First Nation, who was represented at the ceremony, said: "Today marks a great milestone – one that reflects the dedication and vision of many since 2015… Our collaboration on this important mining project is a testament to what can be accomplished when respect, partnership, and our communities lead the way."

The safety record during construction is also drawing attention, with more than 5.3-million hours worked without a lost time incident.

"The safety record at Blackwater Mine is an exceptional achievement and a leading statistic globally," said Artemis president and COO Jeremy Langford.

Perenti awarded A$1.1bn contract at Endeavour's Mana mine

Mining services group Perenti has been awarded a five-year underground mining contract valued at A$1.1-billion at Endeavour Mining's Mana gold complex in Burkina Faso, the Australian contractor announced recently.

The contract will be delivered through Perenti's joint venture subsidiary, Underground Mining Services Burkina Faso (UMS), a partnership with local company Dynamic Mining Supply. UMS will oversee underground mining operations at the Siou and Wona areas of the Mana complex.

Perenti has operated at Mana since 2018 through African Underground Mining Services Burkina Faso, providing underground mining and support services.

The new contract, which takes effect from June 1, includes underground development, production, and related mining services over a 60-month period. The capital requirements for 2025 have already been accounted for in Perenti's financial guidance.

"It is very pleasing and positive to announce the expansion of the Mana contract with Endeavour," said Perenti MD and CEO Mark Norwell. "This contract is consistent with our guidance for FY25 and will contribute strongly in FY26 and beyond. Our team continually delivers exceptional value for our clients, and this is clearly demonstrated by this long-term contract for expanded operations at the Mana complex."

Gabrielle Iwanow, president of contract mining at Perenti, highlighted the importance of the expanded scope and local partnerships. "This contract, with expanded scope demonstrates the enduring nature of our relationship with Endeavour. We reiterate our commitment to delivering for our clients and creating enduring social and economic value in the communities in which we operate. We are proud to be working alongside our local JV partner Dynamic Mining Supply to take further steps to support development of local procurement, capability and employment in Burkina Faso. The success of these partnerships is built on trust, reliability, and the outstanding capabilities of our team."

The Mana complex is operated by Semafo Burkina Faso, a subsidiary of Endeavour.

BHP to fund copper ISR trial

EnviroCopper is set to conduct a site environmental lixiviant trial (SELT) to test copper extraction via in-situ recovery (ISR) at its Kapunda copper-gold project, following approval from the South Australian Department for Energy and Mining.

To take place from the December 2025 quarter to the March 2026 quarter, the SELT will form a 'proof of concept' for oxide copper extraction using the ISR technique in a shallow fractured rock aquifer setting. The in-ground SELT work will span 90 days.

EnviroCopper initially executed the research agreement with OZ Minerals in August 2022. Following BHP's $9.63 billion acquisition of OZ Minerals in May 2023, the Big Australian will now commit research funding to the trial.

If the trial is successful, it will lead to feasibility studies and launching a mining lease application for a copper ISR mine at Kapunda.

"This is another strategic win for EnviroCopper in the regulatory space, enabling junior companies to explore for potential ISR projects for energy metals, within an exploration licence, thereby minimising time and costs," EnviroCopper managing director Leon Faulkner said.

"We look forward to taking this ISR template to our other project at Alford West and future projects."

Alligator Energy holds a 15.6 per cent stake in EnviroCopper, with the option to acquire up to 50.1 per cent of the company.

The emerging uranium player said the investment complements its "existing and substantial in house ISR development and production expertise" and its "ISR footprint to include an additional future in-demand commodity", meaning copper.

"This is exciting news for EnviroCopper and for Alligator," Alligator Energy chief executive officer Greg Hall said.

"The well pattern, wellhouse and associated earthworks for the Kapunda trial are all complete, and further preparation works are underway.

"We look forward to observing the trials and EnviroCopper receiving results which informs and builds upon the ISR tool kit they have been developing. There is substantial expansion opportunity in the right settings for this technology in ISR copper when proven."

Flooded mine in Congo is latest threat to global copper supply

The status of one of the world's most important copper mines remains clouded in uncertainty, more than a week after seismic activity caused widespread flooding deep below ground.

Ivanhoe Mines's Kamoa-Kakula complex in the Democratic Republic of Congo is one of the world's top sources of copper and was on course to become the third-biggest supplier of the key energy-transition metal this year. Yet its current condition is a mystery, with contrasting messages from its biggest shareholders.

Some information has been disclosed: water levels have risen after pumping and electrical infrastructure in the Kakula underground mine was damaged. Ivanhoe's Chinese partners – Zijin Mining Group Co. and CITIC Metal – are helping to secure powerful pumps that can help remove that water.

The impacted mine accounts for at least 70% of the complex's current production, according to a note from analyst at Citigroup Inc. The flooding could shut the Kakula underground operation until at least the fourth quarter, Citi said, while adding that output can be ramped up without significant cost once the water has been pumped out.

Toronto-based Ivanhoe declined to comment, but said it plans to provide an update next week.

Ivanhoe has said that there is damage to cables and pipework needed to pump water out of the mine, and that it was working with experts to evaluate the cause and effect of the seismic activity. One person who visited the site earlier this week said that a lot of water had entered the mine and workers were not being allowed to enter.

The incident at Kamoa-Kakula and its fallout underline the vulnerability of the world's vital copper supplies. The metal – used in everything from electric cars and power grids to water pipes – is essential to efforts to decarbonize the global economy, yet many investors and mining executives expect future production will struggle to meet demand.

Supply Shocks

In the past 18 months, there have been several supply shocks. Fellow Canadian miner First Quantum Minerals Ltd. was forced to shutter its biggest copper mine in Panama after widespread protests, while Anglo American Plc is among the major producers to scale back output amid operational problems.

The new uncertainty comes in a period of tight copper supplies. Despite President Donald Trump's trade war fuelling concerns about global growth, the metal is being buoyed by resilient demand from No. 1 consumer China.

Kamoa-Kakula has been one of mining's great success stories in recent years. Discovered by billionaire Robert Friedland, Ivanhoe's chairman, and developed swiftly since Zijin invested in the project a decade ago, it taps into one of the world's richest copper seams and has helped make Congo the second-biggest producer of the metal.

Now it faces its biggest challenge. Ivanhoe reported on May 20 that two days earlier it had temporarily suspended operations at Kakula underground following seismic activity.

Its Chinese co-owner, Zijin, went further, saying there had been a roof collapse and full-year production was likely to be impacted. Ivanhoe quickly disputed this account, saying there was no evidence of collapsing stopes or structural pillars. It said the potential impact on output would only be determined once a full investigation was completed.

But, within days, Ivanhoe withdrew its 2025 output guidance of 520,000 tons to 580,000 tons for Kamoa-Kakula.

With only sparse information to go on, analysts have estimated that 84,000 to 275,000 tons of copper output could be lost this year. That would potentially wipe out a sizable chunk of the 289,000-ton global surplus forecast for this year by the International Copper Study Group.

"There is high uncertainty on the timing of a restart and the level of remediation or mine redesign which may be needed," Goldman Sachs Group Inc. said in a note recently.

For now, Kakula's concentrator facilities can process sizable surface stockpiles, which means there hasn't been any immediate interruption to supplies.

In a recent statement, Ivanhoe said it was pumping 1,000 liters (264 gallons) of water every second from the shallower western section of the underground mine, but its team was trying to increase that to above 3,000 liters to stabilize levels. Ivanhoe didn't mention the eastern section of the mine, where structural damage was flagged by Zijin.

Ivanhoe has said the complex's Kamoa underground and processing operations continue to run normally, and Kakula's surface infrastructure is unaffected.

Zijin and Ivanhoe both hold 39.6% of Kamoa-Kakula, while Congo's government has a 20% stake. Zijin also owns more than 10% of Ivanhoe and CITIC is the Canadian miner's biggest shareholder.

Burkina Faso sees restart of gold mines boosting output in 2025

Burkina Faso is poised to increase its industrial gold mining this year as a project by Mauritius's Soleil Resources International rises to full production and a new mine by Australia's West African Resources starts output later this year.

Production by the country's large-scale operations will increase by 4% to 55.7 tons this year, Aristide Belemsobgo, director general of mines and geology at the Ministry of Energy, Mines and Quarries said in an interview recently.

Gold has been identified as Burkina Faso's main source of export revenue by junta leader Ibrahim Traore, who came to power following a 2022 coup. Still, production has suffered in recent years as deteriorating security conditions in the West African nation forced some mines to shut.

Soleil Resources returned the Youga mine in the south to production in October, Belemsobgo said. West African Resources' Kiaka mine, situated in the southeast, is on schedule for first gold in the third quarter, he said, confirming an earlier update from the company.

Belemsobgo declined to give an outlook on artisanal gold mining. Last year, small-scale mines produced 8.1 tons, bringing combined national output of 61.5 tons, he said.

The increased output could help provide the funds for Traore to fight an Islamist insurgency that's worsening in the West African country, after it cut ties with most of its western partners and drew closer to Russia. Gold prices have risen this year to record levels.

Burkina Faso's junta revised the country's mining code in 2023 to enable it to receive more in royalties during boom times.

Perpetua receives additional funding for Stibnite project from US Army

Mining company Perpetua Resources said it has been awarded up to $6.9-million in additional funding from the US Army for its Idaho antimony and gold Stibnite project.

The Pentagon-backed mine, which would be the country's first antimony project, has an estimated reserve of 148-million pounds of the metal used in bullets and tanks, as well as in alloys for electric-vehicle batteries.

China, responsible for nearly 60% of globally mined antimony in 2024, banned exports of the metal to the United States in December last year, prompting efforts to increase production within the US.

This supplemental award will allow Perpetua to expand the research and support the US Army's objective of establishing a fully domestic "ground-to-round" antimony trisulfide supply chain.

"Advancing America's capabilities to process minerals critical to national defence is essential for our long-term mineral independence and resilience," said CEO Jon Cherry.

The company said that with the receipt of this additional funding, its total awards from the Department of Defence exceed $80-million, including the $15.5-million received under an Ordnance Technology Initiative Agreement in August 2023.

Recently, the company received the final federal permit, the Clean Water Act Section 404, from the US Army Corps for the project.

Teck sees no impact to copper guidance from Chile disruptions

Canada's Teck Resources said recently it had temporarily shut down the semi-autogenous grinding mill at its Carmen de Andacollo (CdA) copper operation in Chile owing to a mechanical issue, but stressed that it expected no material impact to production for the year.

The Vancouver-based miner estimated repairs would take about a month and said it planned to reschedule other maintenance work to coincide with the downtime.

"We do not expect a material production impact from the downtime, and our previously disclosed guidance for 2025 total annual copper production and 2025 annual copper production for CdA remains unchanged," Teck said in a statement.

The company also reported an unrelated outage of the shiploader at its Quebrada Blanca (QB) port facility in northern Chile. Repairs were also expected to take about a month. However, mining and plant operations at QB remain unaffected, and Teck said it had the capacity to ship via alternative ports.

As a result, Teck reiterated that its 2025 copper production and sales guidance for QB is unchanged.

Many clean returns: conveyor belt scraper placement

Primary, secondary and tertiary cleaners are all Specially engineered for purpose and placement.

Knowing the location and number of belt cleaners required for a belt conveyor system is critical to improving safety, increasing component life and reducing clean-up costs. A common design problem is fitting belt cleaners in the optimum locations. There are structural, spatial and safe access considerations that can offer limitations. Discharge chute configuration and installation of a dribble chute to capture extra discharge may also need to be factored into the design. This article will discuss design calculations for the location of secondary cleaners.

PLACEMENT AND POSITIONING

The Conveyor Equipment Manufacturers Association (CEMA) defines the secondary position as the space between the head and snub pulley on the return run of the belt. [**Figure 1**] Unfortunately, structural designs often result in a very short section of belt surface between the head pulley and the snub pulley which is the ideal location for many secondary cleaner designs. This short distance allows little room for belt cleaners in the secondary position which is further complicated by the space needed for a dribble chute. In addition, designers often locate work platforms based on major components, overlooking access for belt cleaner inspection or maintenance. Belt cleaners typically require more attention than major components to ensure system efficiency because the blades are wear components that must be maintained at optimal cleaning pressures.

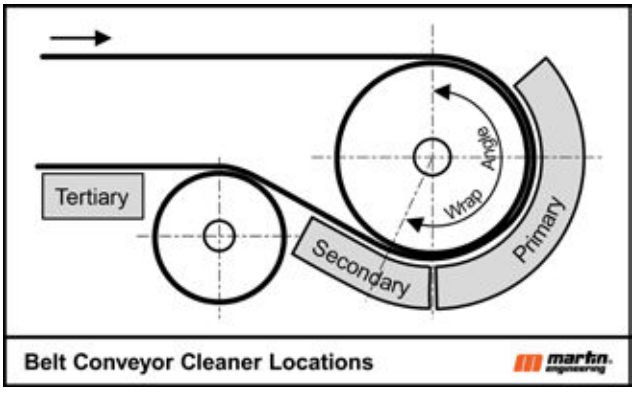


Figure 1.

DESIGN AND INSTALLATION CONSIDERATIONS

There are many simple options designers should consider:

1. **Is the drive pulley wrap angle really needed or are you just applying it from habit?**
   A common default wrap is 210 degrees created by the

Larger than minimum head pulley diameter for adequate belt cleaning with two primaries and one secondary cleaner.

position of the snub pulley. The gap between the head pulley and snub is an ideal location for a secondary cleaner but the combination of pulley diameters and wrap angle may make mounting a secondary difficult and maintenance nearly impossible. We recommend utilising an updated engineering design program that uses either the DIN or CEMA methods for the calculation of accurate tension values and the required wrap angle, Θ.

2. **Consider using a larger diameter head pulley.**
   Choosing a head pulley based on the minimum diameter may seem like it saves money, however, MSHA reports that up to 85% of maintenance problems are due to fugitive materials, which increase costs for cleanup, labor, and equipment replacement[1].A larger head pulley can allow the installation of two cleaners in the primary position and enough snub pulley space for one or two cleaners in the secondary position, significantly reducing the amount of fugitive material.

3. **Place a priority on ergonomic access to the belt cleaners.**
   Maintenance personnel can spend up to a third of their time merely gaining access to the equipment. Designing access to seldom-inspected or -maintained components based on minimum walkway codes raises costs. Consider structure and work platforms that allow belt cleaner inspection and maintenance.

4. **Consider using motorised drive pulleys.**
   Motorised pulleys offer energy advantages and weight savings and open up space for belt cleaner installation and maintenance. Since all rotating components (including the main bearings) are located inside the pulley, the external stub shafts need minimal space to be mounted to the structure.

5. **Consider professionally trained installation.**
   Belt cleaners must be mounted properly, often within ± a few millimeters, to perform optimally and limit the possibility of damaging the belt. Contracting with the belt cleaner supplier ensures proper installation with minimal adjustment and that the new chute will retain a clean professional look.

CALCULATING THE ADEQUATE BELT TENSION

A critical design requirement is to determine the amount of wrap around the drive pulley required to provide the adequate conversion of torque from the drive into belt tension sufficient to move the belt without slipping. It is interesting to note that the fundamental relationship describing this transfer does not depend upon the pulley diameter, only the coefficient of friction, μ, between the belt and pulley and the wrap angle, Θ and the belt tensions required to prevent slip. [**Figure 2**]

SECONDARY BELT CLEANER LOCATION GEOMETRY

Assumption: Top and bottom runs of the conveyor belt (X) are parallel entering head pulley and leaving snub pulley. [**Figure 3**]

Some secondary cleaners must be mounted at least 50 mm from the point the belt leaves the head pulley so this offset

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

Where:

T_1 = Belt tension entering the drive pulley

T_2 = Belt tension leaving the drive pulley

μ = Coefficient of friction between drive pulley and belt

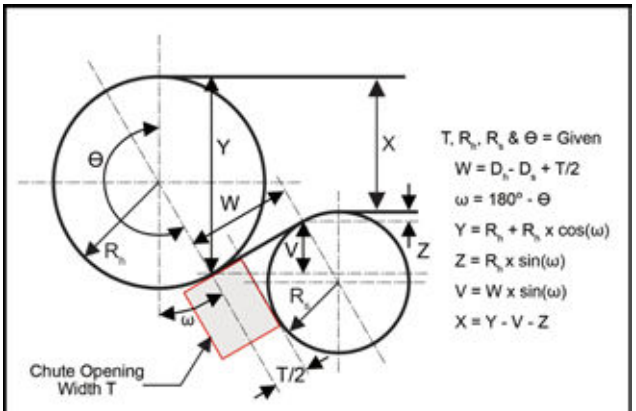
θ = Angle of belt wrap around drive pulley (radians)

Drive Pulley Tension Relationship

Figure 2.

Variables:

Θ = Wrap angle of belt around head pulley.
ω = Wrap Angle, Θ, - 180 degrees.
H = The height of the opening for the Secondary belt cleaner blades and frame installation.
Rh = Radius of Head pulley plus lagging, plus belt thickness
Rs = Radius of Snub pulley plus lagging, plus belt thickness. (Snub Pulley Diameter default value: 0.64 × head pulley diameter per DIN 22101)
T = The width off the opening for the Secondary belt cleaner blades and frame installation.
W = Length of belt segment tangent to both the Head and Snub pulleys.
X = Distance between top and bottom runs of the conveyor belt.
Y = The vertical distance between the top run of the conveyor belt on the Head pulley and the tangent point where the belt leaves the Head pulley and starts the return run.



Secondary Mounting Location Basic Layout

Figure 3.

also needs to be considered if required. In addition, the X dimension should be checked with the idler dimensions for adequate installation space. [**Figure 4**]

A similar analysis for the location of a Martin Precleaner will show that with a 1200 mm diameter head pulley, two primary cleaners can be installed in addition to a secondary cleaner. The addition of tertiary cleaners would be possible but may not be necessary if two precleaners and a secondary are mounted on the head pulley.

$T/2 = 150$ mm
$D_h = 1200$ mm $R_h = 600$ mm
$D_s = 800$ mm $R_s = 400$ mm
$\Theta = 210°$
$\omega = \Theta - 180° = 30°$

$W = D_h - D_s + T/2 = 550$ mm
$Y = R_h + R_h \times \cos(\omega) = 1119.6$ mm
$V = R_s - R_s \times \cos(\omega) = 53.6$ mm
$Z = W \times \sin(\omega) = 275$ mm
$X = Y - V - Z = 791$ mm

Secondary Mounting Space Example

Figure 4

CONCLUSION

A belt cleaner system should be properly specified, designed and installed to gain the direct and indirect long-term cost benefits of reduced fugitive material, but compliance is an issue as well. OSHA, 1926.1412(d)(1) and MSHA 75.362 state, "A competent person must begin a visual inspection prior to each shift the equipment will be used, which must be completed before or during that shift."[2] Safe access with adequate space for installation, maintenance and inspection is critical to supporting longer system life and a lower cost of operation.

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Engineering giants: revolutionising modern opencast mining

Opencast mining has evolved into a high-volume, high-efficiency operation, demanding ever-larger machinery to keep pace with the increasing scale of excavation. In today's large-scale mining projects, cutting manpower costs while maximising output per shift is crucial. This drive for efficiency has led to the systematic expansion and refinement of mining equipment, enabling operations to dig deeper and extract valuable resources with greater precision.

Deposits as deep as 300 meters are already being mined profitably, and newer opencast sites are reaching depths of up to 500 meters. As technology advances, mining economics continue to push boundaries, making it possible to extract materials from deposits with ever-higher overburden-to-mineral ratios. This shift has placed the primary focus on cost-effective overburden removal, with mineral extraction becoming a secondary objective.

To achieve this, mining operations increasingly favour continuous digging and handling systems, ensuring material is excavated and transported seamlessly with minimal disruption.

BWES: ENGINEERING EXCELLENCE IN CONTINUOUS MINING

The continuous mining method – utilising bucket-wheel excavators (BWEs) for excavation, belt conveyors for material transport, and boom stackers for overburden dumping—was originally developed for large-scale lignite mining in Germany. With initial capacities of 24,000 cubic meters per day, this system proved highly efficient.

Today, bucket-wheel excavators are at the forefront of mining operations worldwide, actively used in the extraction of coal, phosphate, bauxite, ore, and tar sands across multiple countries. These mechanical giants have been shaping the mining industry for over a century, with some of the earliest models dating back to the 1920s.

Designed for continuous excavation, BWEs revolutionised large-scale open-pit mining, allowing for the removal of thousands of tons of material daily transforming the way resources are extracted from the earth. Basic parameters for opencast planning are an exact knowledge of the geological stratification, compressive strength of the in-situ material, and control of the water inflow in the pit

Bucket wheel excavators would go on to prove successful not only in opencast cast mining operations, but also in earth moving applications. For these, special compact bucket wheel excavators were developed and deployed worldwide for a number of construction and land restoration projects.

Trevor Barratt MD of *Coal International* takes a look at how BWEs have developed over the years.

ENGINEERING EVOLUTION: THE RISE OF MASSIVE BWES

The post-World War II era saw a monumental leap in mining technology, with German firms such as Takraf and Freid Krupp spearheading the development of the first truly massive bucket-wheel excavators (BWEs). By the 1950s, these colossal machines were redefining the scale of open-pit mining – boasting wheels over 16 meters (52 feet) in diameter, weighing a staggering 5,500 tons, and cutting swaths of up to 180 meters (600 feet) in a single pass.

Since the 1990s, BWEs have grown to mind-blowing dimensions, with machines like the Bagger 293 setting records. Towering at 96 meters (315 feet) tall, stretching 225 meters (738 feet) long, and tipping the scales at 14,200 tons, it remains one of the largest land vehicles on Earth—a true testament to the engineering excellence of German manufactures.

A LEGACY OF INNOVATION: FROM EARLY DESIGNS TO MODERN GIANTS

The first BWEs emerged in the 1920s, designed primarily for removing overburden in open-pit mining. These early models were relatively modest compared to today's towering giants. However, technological advancements accelerated post-WWII, and by the 1950s, German mining firms – renowned for their engineering prowess – pioneered some of the world's first ultra-large BWEs.

Modern open-cast mining employs two primary methods:

- Continuous mining, where digging, loading, and transportation occur in sequence using traditional equipment such as shovels, draglines, front-end loaders, and scrapers.
- German-engineered mining, which integrates multiple digging elements into a seamless, continuous excavation process.

Among these technologies, bucket chain excavators and bucket-wheel excavators serve distinct roles. While bucket chain excavators make vertical cuts, they are less suited for selective mining. BWEs, on the other hand, swing their wheels horizontally, allowing for precise removal of individual layers – making them ideal for selective mining.

ADVANCEMENTS IN BWE DESIGN

By 1950, smaller BWEs were typically built without crowd mechanisms, while larger models featured a crowd system – where the wheel boom advanced toward the mining face to set the cut. However, modern high-capacity BWEs have overwhelmingly shifted to crowd-less designs.

This transition offers key advantages:

- Lower structural weight, resulting in more efficient operation.

- Simplified design, reducing complexity and maintenance costs.
- Enhanced durability, thanks to advancements in alloyed materials that extend the lifespan of crawler components.

With continuous improvements in bucket-wheel excavators, belt conveyors, and boom stackers, modern open-cast mining remains focused on efficiency, scale, and precision. As mining operations deepen and expand, the role of BWEs continues to grow, ensuring the industry pushes technological limits further than ever before.

BUCKET CHAIN EXCAVATOR

1960s: The Rise of Large-Scale BWEs in German Brown Coal Mining

By the 1960s, Germany's brown coal mines operated on an immense scale, with massive bucket-wheel excavators (BWEs) slowly advancing, stripping away overburden to expose valuable deposits. Some of these behemoths, excluding ancillary equipment, weighed an astonishing 217,000 tons. Despite the increasing depth of deposits, the sheer scale of operations brought significant economic advantages.

The energy required for mining was immense—as reflected in extraction statistics:

- 1960 – Removing 2.8 cubic meters of overburden per tonne of brown coal mined.
- 1975 – Increased to 3.8 cubic meters per tonne.
- 1985 – Further rising to 4.8 cubic meters per tonne.

Over the past three decades, specialised companies have emerged, focusing on the development of plant and equipment for open-cast mining. Among them, VVB Takraf, an industrial association at the time once claimed that 50% of the world's brown coal was mined using their equipment – a testament to their engineering dominance.

TAKRAF remains a powerhouse in bucket-wheel excavator manufacturing, designing high-capacity machines for continuous mining. Their excavators efficiently remove overburden and extract coal, sand, and gravel. TAKRAF's machines can operate with capacities of up to 20,000 m³/h and work on benches ranging from less than 5 meters to approximately 50 meters.

1970s: Expansion and Engineering Innovations in BWEs

By 1979, Bucket-Wheel Excavators (BWEs) had evolved to handle output rates of up to 30,000 cubic meters per day, typically fitted with suspended luffing discharge booms measuring 30 meters, or even 40 meters in exceptional cases. These powerful machines were deployed across the world, operating in:

- Coal mines – Australia, India, Indonesia, Greece, Yugoslavia, Romania, and Germany.
- Phosphate mines – Togo and Senegal.
- Bauxite mines – Surinam and Ghana.
- Tar sand operations – Canada.
- Ore mines – USSR and Zambia.

As mining technology advanced, digging width and haulage systems were constrained by boom length. A workaround was introduced: a crawler-mounted transfer conveyor linking the excavator to onward transport. However, this solution required additional personnel, as the excavator's movement had to be carefully coordinated with the conveyor system.

To maximise efficiency, engineers designed BWEs with separate crawler-mounted loading units, connected via discharge conveyor bridges instead of conventional booms. This system significantly improved the process.

- Minimised interference between excavation and material loading.
- Maintained a consistent centre transfer point, critical for belt conveyor systems.
- Enabled vertical digging across multiple working levels, enhancing mining flexibility.

By this period, these advanced BWE systems were deployed worldwide, including:

- France & Romania – Operating at 200,000 cubic meters/day.
- Poland – Scaling up to 425,000 cubic meters/day.
- Greece, Turkey & Australia – Developing new deposits with systems nearing 62,000 cubic meters/day.

OPTIMISING DIGGING HEIGHT & WHEEL DESIGN

To match growing output demands, engineers increased digging height and bucket-wheel diameter, ensuring an optimal balance between excavation depth and efficiency.

The latest bucket wheels adopted a cell-less cone-type design, improving excavation performance:

- Material dropped from buckets onto an inner rotating cone, gaining extra acceleration before moving to the wheel boom belt.
- A fixed chute scraped and cleaned the cone, preventing clogging – even when handling sticky or adhesive material.
- Wear plate liners safeguarded vital components, extending equipment lifespan.

The bucket wheel design with closely spaced cutters permitted the excavation of compact ground formations such as solidified sand, tuffaceous material, and cemented conglomerates. The numerous cutters at the wheel periphery, all fitted with teeth, produced small lumps even from compact in-situ material.

Bucket wheel drives for smaller excavators at the time were pole changing motors, or a two- motor to drive in so-called' father and son arrangement' (main and auxiliary motor) Larger bucketwheels had multi- motor drives, the bucket wheel speed was adjustable electrically from the excavator operator's cab.

The BWEs power was supplied by way of the cable reel mounted on the loading unit. To achieve the steady flow of material with crowd- less bucket wheel excavators, the slewing speed must be controlled in relation to the slew angle for such controlled movements the larger BWEs were equipped with a special automatic stick for the following functions.

The slewing speed is controlled automatically in relation to the cosine of the slew angle, after a reference value was being fed into the control system. When the slew angle preset for the end of the slewing motion has been reached, the slewing movement is switched off automatically. The excavator then advances by the preset increment of cutting depth. Indicating instruments show the operator the depth of advance travelled, and the distance from a reference point. Each of these three functions is initiated by actuation of a control element.

The automatic control can be interrupted in any position, and no new settings were required. Numerous safety devices were installed to ensure a trouble-free operation and to avoid any damage to the equipment.

TRANSPORT OF MATERIALS

Transport of materials in large-scale operations with continuous handling flow was carried out by conveyors. These would deliver the pay minerals to the power station or to a loading point at the edge of the pit and take the overburden to the dump site.

In sites with varying stratification and selected mining of the deposit, the conveyors from the individual digging benches converge in a conveyor collecting point. Shuttling heads are used to direct the material alternately to the onward conveyors for pay mineral to the consumers or transfer it to the overburden conveyors which lead to the pit depending on the length of the conveyor, up to six drive motors are installed in individual conveyor flights. Four drives are located in the head drive terminal unit that is to say that the discharge end, and two drives in the tail terminal.
z
Conveyors at the mining face and on the dump were of the moveable design. Individual conveyor frames with garland idler sets were connected by rail and could be moved sidewards by means of a bulldozer with side boom crane, to which a roller dragbogie was attached. Transport crawlers were in use at the time for shifting of the larger drive terminals. They could also be used for the transport of heavy loads and as a tractor vehicle. Operations were usually controlled and monitored from a plant control centre with a conveyor control station at the end of the pit.

Bucket wheel excavators would go on to prove successful not only in opencast cast mining operations, but also in earth moving applications. For these, special compact bucket wheel excavators were developed and deployed worldwide for a number of construction and land restoration projects.

1995- PRESENT

One machine that stands out among engineering marvels is the TAKRAF SRs 8000, more commonly known as the Bagger 293. Manufactured in 1995, this colossal bucket-wheel excavator holds the Guinness World Record as the heaviest land-based vehicle ever built, weighing an astonishing 14,200 tons. Developed by the German engineering firm TAKRAF, the Bagger 293 was primarily used for lignite mining in Germany's Rhineland region. With a towering presence and unmatched excavation capacity, it became a defining symbol of engineering ingenuity, showcasing humanity's ability to design machines capable of handling massive-scale excavation efficiently.

Over the years, mining technology has pushed these machines even further. Today, similar excavators are capable of operating in extreme conditions, including temperatures as low as -45°C, and are increasingly being integrated with automation to enhance precision and efficiency.

FUTURE INNOVATIONS

Looking ahead, mining technology will continue advancing to improve safety, efficiency, and sustainability. Today's modern designs focus on automation and electrical power for improved efficiency, one example being the Barracuda bucket wheel excavator manufactured by Schlam in Australia, a revolutionary mining concept designed to enhance efficiency and safety in mining operations. It combines advanced automation and digitisation technologies to streamline material handling and improve precision. One of its standout features is its ability to handle overburden systems with a capacity of 6,700 loose cubic meters per hour, integrating seamlessly with conveyor systems and spreaders.

Other developments are:

Automation & AI Integration: Companies are incorporating AI-powered systems to optimise excavation processes, reducing human intervention and improving precision.

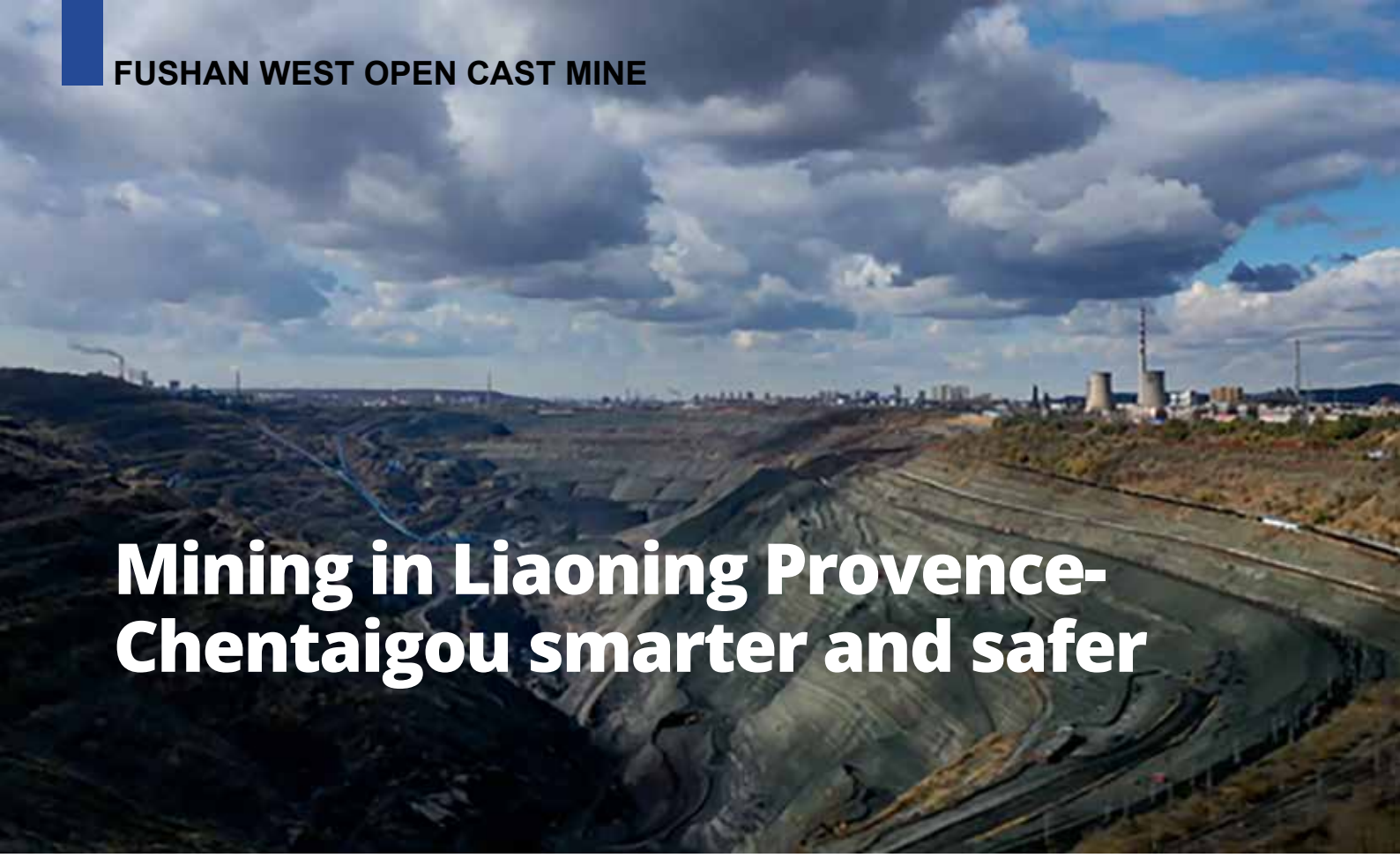
Smart Monitoring Systems: Advanced sensors and IoT technology allow real-time monitoring of machine performance, predictive maintenance, and remote operation.

Improved Durability & Materials: New designs feature stronger, lightweight materials that enhance durability while reducing operational costs.

Electric & Hybrid Models: Manufacturers are developing electric and hybrid BWEs to reduce carbon emissions and improve energy efficiency

CONCLUSION

Engineering innovations have revolutionised opencast mining, making it safer, more efficient, and environmentally responsible. As technology advances, mining will become even more automated, precise, and sustainable ensuring that resource extraction continues to meet global demands while minimising ecological impact. The future of mining belongs to innovation, and the giants of engineering will continue shaping its evolution.



Mining in Liaoning Provence- Chentaigou smarter and safer

It is a far cry from the 1980s when *Coal International* reported on the Fushan West Open Cast mine in Liaoning province. It was hard to imagine without actually seeing it, a mine that was 6.6 km long,2.2 km wide and 280 m deep, and yet this was the size of the operation represented by the West Open Cast Mine.

First developed in 1914 the mine in the 80s covered an area of 10km 2 and produced around 5 million tons per year.

This mine was notable not only for its coal production but also for its extraction of oil shale, making it a dual-purpose operation.

Today the Fushun West Open Cast Mine is no longer in operation as a coal mine. It has been largely depleted of its coal reserves and has transitioned to focus on oil shale extraction.

There are still 21 coal mines operating in Liaoning Province. These mines have an annual production capacity of 41.24 million tons. The number of active mines has decreased over time due to resource depletion and environmental concerns.

Economically, the remaining coal mines contribute to local employment and energy supply, supporting industries like steel production. However, the decline in coal reserves and the shift towards renewable energy have reduced the sector's overall economic significance.

Trevor Barratt MD of both Coal International and Mining and Quarry World looks at how the Provence has developed over time and looks at the sustainability initiatives being developed with the construction of China Minmetals Corporation Chentaigou iron ore mine

EARLY COAL DEVELOPMENT:

Coal mining in Liaoning began in the early 20th century. The Fushun coal mines, for instance, were developed around 1905 by Russian operations and later taken over by the South Manchurian Railway Company in 1907. By the 1930s, these mines accounted for 75% of Manchuria's coal production.

Benxihu Colliery: This coal mine in Benxi, Liaoning, has a tragic history. Originally a joint Japanese Chinese project, it came under Japanese control during the 1930s. The mine is infamous for a devastating gas and coal-dust explosion in 1942, which resulted in over 1,500 deaths, making it one of the worst mining disasters in history.

Post-War Era: After World War II, the mines were damaged but were later restored and modernised. By the mid-20th century, Liaoning's coal mining industry had expanded to include not only coal extraction but also the production of chemical by-products and synthetic petroleum.

THE MINING LEGACY OF LIAONING PROVINCE: PAST, PRESENT, AND FUTURE

Liaoning Province, with its 65 identified mines, has long been a powerhouse of mineral wealth, fuelling China’s industrial growth. From the historic extraction of iron, manganese, zinc, gold, and copper, to innovative explorations for deep mineral resources, the province stands at a crucial intersection of tradition and innovation.

A LEGACY FORGED IN ORE

Mining has been deeply intertwined with Liaoning's economic and infrastructural development. The 39 active mines contribute significantly to regional and national industries, shaping the province into a key player in China’s resource economy. Historical mining centres like Benxi

and Anshan, once vital during China's industrial revolution, continue to evolve with new extraction technologies.

THE ENVIRONMENTAL RECKONING

While mining has propelled economic growth, it has also left a lasting imprint on Liaoning's landscapes. Issues such as deforestation, soil degradation, and pollution have challenged sustainability. In recent years, the government has ramped up mine restoration projects, emphasising reforestation, water purification efforts, and eco-friendly mining techniques. Companies are exploring carbon capture methods and investing in renewable energy to reduce mining's ecological footprint.

LOOKING AHEAD: INNOVATION AND SUSTAINABILITY

Future mining operations in Liaoning are focusing on deep-seated mineral deposits, utilising AI-driven geological mapping, autonomous extraction equipment, and green energy solutions. The push toward sustainable mining is becoming a defining feature, ensuring resources are harnessed without compromising environmental integrity. Initiatives like waste-reduction programs and closed-loop mining systems aim to minimise impact while maximising efficiency.

LATEST DEVELOPMENTS

Recently, a major project, the Chentaigou Iron Mine, was launched in Anshan, Liaoning.

The groundbreaking ceremony for the project took place on June 26, 2023, marking the start of construction. This mine is notable for being China's first ultra-deep well and ultra-large-scale iron ore mining project. It aims to enhance the country's iron ore strategic reserve system and support the steel industry's supply chain.

The Chentaigou Iron Mine, located in Anshan, Liaoning Province, China, is a significant project under China Minmetals Corporation. It is a proposed super-large iron ore mine with a design capacity of 11 million metric tonnes per year and total resources estimated at 1,216 million tonnes. The mine is expected to produce 4.7 million tonnes of iron concentrate annually.

As one of the first key projects under the Cornerstone Plan of China, Chentaigou Iron Mine Project plays a critical role for China Minmetals to safeguard national mineral resources and build a mining powerhouse. It is currently advancing under the guidance of China Minmetals. The project is firmly anchored to the goal of commencing trial

production by July 2026, with a focus on four major controls to drive progress. Efforts are concentrated on accelerating tunnel engineering, scheduling reverse network plans, and facilitating critical construction. The aim is to complete 295,000 cubic meters of critical construction in 2025 and ensure that over 90% of tunnel engineering is finalised by year-end, laying a solid foundation for transition to production on schedule in 2026.

STRENGTHENING THE FOUR MAJOR CONTROLS TO BUILD A HIGH-QUALITY PROJECT.

As part of its unwavering implementation of the strategic directives from China Minmetals and Minmetals Mining, Chentaigou Iron Mine is advancing its mission by focusing on safety, timeline, quality, and investment control to systematically execute annual priorities, enhance oversight, and refine process management. The goal is to reduce labour, save time, lower costs, and improve efficiency. In terms of safety, it is required to deepen zero-tolerance for accidents and catastrophic risks. Besides, the project reinforces defences, upholds safety baselines, and strictly avoids crossing red lines to ensure stable safety and environmental performance throughout the year. When it comes to timeline, the object adopts a goal-oriented approach. The 36-month construction timeline is broken down into detailed roadmaps and blueprints. By reverse scheduling and visualising progress, the team ensures all critical tasks are completed by year-end. The quality aligns with China Minmetals' quality culture. The project follows the philosophy that quality goes first. Thus, rigorous quality management is applied to critical works, permanent infrastructure, and underground works, striving to create a high-quality project that endures. As for investment control, the project rigorously enforces a budgeting and final accounting system to reduce costs for mining equipment, general bulk materials, and services. It strengthens the management of engineering change approvals and enhances oversight of investment expenditures.

Focusing on Milestones, Accelerating Progress at Full Throttle. Since January of this year, the Chentaigou Iron Mine Project has maintained a full momentum, relentlessly pursuing construction goals by prioritising tunnel engineering and advancing surface-level infrastructure. During the first quarter of 2024, the project successfully navigated challenges including complex geological conditions, harsh weathers in winter, and disruptions caused by the Lunar New Year holiday. To mitigate delays and accelerate progress, the project team bolstered technical support, dynamically adjusted construction plans, and optimised the layout of the coarse crushing chamber, which collectively shortened the overall schedule and solidified the groundwork for completing underground engineering. Post-holiday safety and operational readiness were prioritised through rigorous inspections, focusing on worker retraining, site safety protocols, equipment functionality, and temporary power systems. By February 25, all project sections resumed operations following the winter hiatus, initiating large-scale earthwork excavation and transportation. As of March 24, cumulative achievements included 807,400 cubic meters of earthwork excavated, 12,600 meters of prestressed anchor cables installed, 29,000 meters of rock bolts completed, and 40,000 square meters of slope surfaces hardened. Meanwhile, the project is intensifying efforts to advance the construction of the mineral processing plant's main structure. The bidding process for the plant was officially finalised on March 26, and construction teams are now being urgently mobilised to the site to ensure the smooth and timely commencement of the main structure.

STRENGTHENING THE PARTY'S LEADERSHIP TO UNITE EFFORTS AND OVERCOME CHALLENGES.

The Chentaigou Iron Mine has vigorously upheld the tradition of establishing Party branches at the grassroots level. By advancing standardised and exemplary Party branches, the project integrates Party-building efforts

with production goals, ensuring that Party building drives production, and production reinforces Party building. Deepening actions under the theme of "raising the Party flag high and showcasing the Party emblem," the branches aim to become hubs for uniting workers, schools for educating Party members, and fortresses for tackling critical challenges. The project firmly puts work safety above all other considerations, adhering to the philosophy that safety risks represent the greatest threat to corporate operations. By focusing on on-site standardised operations and orderly site management, it advances the Five Forces, Five Drives Party-building Safety Initiative in depth. This initiative empowers Party members to play exemplary roles in critical areas such as site governance, civilized construction practices, and clean production, ensuring safety permeates every operational layer.

The project is advancing rapidly, with a goal to commence trial production by July 2026. It focuses on high-quality construction, safety, and efficiency, employing innovative methods like belt transportation in ultra-deep vertical shafts. This approach addresses challenges in ore transportation and improves energy utilisation.

TECHNOLOGICAL INNOVATIONS:

The mine employs ultra-deep well mining techniques, making it one of the first of its kind in China.

It uses belt transportation systems in vertical shafts, which improve energy efficiency and address challenges in ore transportation.

The project emphasises intelligent and green mining practices, integrating modern technologies to enhance safety, reduce environmental impact, and optimise resource utilisation.

STRATEGIC IMPORTANCE:

The mine is a critical component of China's Cornerstone Plan, aimed at safeguarding national mineral resources and strengthening the steel industry's supply chain.

It contributes to the national iron ore strategic reserve system, ensuring a stable and sustainable supply of raw materials for the country's economic development.

The project represents a collaboration between central enterprises and local governments, promoting high-quality industrial development in Liaoning Province.

ENVIRONMENTAL IMPACT

1. **Ecosystem Disruption:** The construction and operation of such a large-scale mine can disrupt local ecosystems, affecting flora and fauna in the region.

2. **Waste Management:** Managing the waste generated during mining operations, including tailings, is a critical concern to prevent soil and water contamination.

3. **Energy Consumption:** The mine's operations require substantial energy, which could contribute to carbon emissions unless renewable energy sources are utilised.

4. **Water Usage:** Mining activities often demand significant water resources, potentially impacting local water availability.

5. Construction Challenges

6. **Geological Complexity:** The mine's ultra-deep well design involves navigating complex geological conditions, which can pose risks like rock bursts and ground instability.

7. **Safety Concerns:** Ensuring worker safety in such a deep and large-scale project requires advanced safety protocols and technologies.

8. **Technological Demands:** The use of innovative methods, such as belt transportation in vertical shafts, requires precise engineering and implementation.

9. **Timeline and Budget Management:** Keeping the project on schedule and within budget while maintaining high-quality standards is a constant challenge.

10. Despite these challenges, the project is committed to adopting green and intelligent mining practices to mitigate environmental impact and enhance efficiency.

Additional mining activities have posed environmental risks, such as surface water pollution from mineral exploitation. Studies have highlighted the need for better management and ecological restoration to mitigate these effects.

Renewable Energy Transition: Liaoning is investing heavily in clean energy, with a $121 billion plan to develop six energy bases, each with a capacity of 10 gigawatts. These bases will include nuclear, offshore wind, pumped hydro energy storage, and other renewable sources. By 2025, the province aims for over 50% of its power generation capacity to come from clean energy.

Green Transformation Initiatives: Liaoning is exploring sustainable development paths, such as promoting green industries and adopting environmentally friendly practices. For example, cross-border e-commerce is being leveraged to transform the industrial structure into a greener and more sustainable model.

Liaoning province has been actively working on environmental strategies and economic transformation to address the challenges posed by its historical reliance on heavy industries and mining.

KEY ENVIRONMENTAL IMPACT & RESTORATION STRATEGIES:

China Minmetals has been actively promoting environmentally responsible practices, ensuring that the mine aligns with national sustainability goals.

Green Mining Initiatives: The mine follows strict green mining standards, focusing on energy efficiency, emissions reduction, and ecological restoration.

- Carbon Reduction Efforts: China Minmetals has implemented energy-saving technologies that significantly cut carbon dioxide emissions – equivalent to planting 825 hectares of trees annually.

- Waste & Pollution Control: The company is optimising equipment and facilities management to reduce waste and improve emission standards.

- Reforestation & Land Rehabilitation: Restoration efforts include afforestation projects and soil erosion control measures to mitigate the environmental footprint.

KEY INNOVATIONS:

- Low-carbon blast furnace technology: China Minmetals has developed a 2,000 m³ low-carbon blast furnace, significantly reducing emissions.

- Gas-based direct reduction ironmaking: A newly developed direct reduction ironmaking device enhances energy efficiency and lowers carbon output.

- Advanced water recycling systems: The mine employs closed-loop water recycling to minimise wastewater discharge.

- Automated dust suppression: High-tech dust control systems reduce airborne pollutants, improving air quality.

- Renewable energy integration: Solar and wind power are being incorporated into mining operations to reduce reliance on fossil fuels.

COMPARISON WITH GLOBAL GREEN MINING INITIATIVES

- Carbon Reduction: The mine's low-carbon blast furnace technology and gas-based direct reduction ironmaking are comparable to Rio Tinto's hydrogen-based steelmaking trials in Australia and Vale's biochar initiatives in Brazil.

- Water Recycling: Chentaigou's closed-loop water recycling mirrors Anglo American's advanced water management systems in South Africa, which aim to reduce freshwater consumption.

- Dust Suppression: The mine's automated dust control systems are similar to BHP's air quality monitoring and suppression technologies used in Australian iron ore mines.

- Renewable Energy Integration: Chentaigou's solar and wind power adoption aligns with Canada's green mining efforts, where mines are increasingly powered by hydroelectric and solar energy.

- While these technologies place Chentaigou among the leaders in sustainable mining, global initiatives often emphasise hydrogen-based steelmaking and carbon capture, which China Minmetals may explore further.

AUTHORS CONCLUSION

The mining industry worldwide as a whole is shifting toward profitability through sustainability, with companies balancing cost control and ESG considerations. These trends indicate that mining is evolving into a smarter, safer, and more sustainable industry.

LONG MAY IT CONTINUE

Out of sight, out of mind

How deficiencies in the carcass of a conveyor belt significantly reduce both performance and longevity levels.

The core structural element of every conveyor belt is its inner carcass, which provides the inherent characteristics such as its tensile strength and elongation (elasticity or 'stretch' under tension). Its primary function is to transmit the tension required to lift and move the loaded belt, while also absorbing the impact energy generated as material is loaded onto the belt. However, there is more to it than that.

Perhaps because the thick outer covering of rubber makes the carcass invisible to the eye is why the rubber covers rather than the inner carcass is widely considered to have the biggest bearing on performance and longevity. Whatever the reason, the carcass is the backbone of every conveyor belt, and its importance should never be underestimated.

THE IMPORTANCE OF THE FABRIC.

Most rubber multi-ply and single-ply belts use synthetic fabrics, most commonly a combination of polyester and nylon (polyamide), referred to as 'EP'. The basis of using a mix of polyester and nylon fabric in multi-ply belts is that it has the best balance of mechanical properties including allowing a conveyor belt to run straight, to trough, to flex round pulleys and drums, stretch, provide transversal rigidity, longitudinal strength and much more besides. Unless the weave pattern has been very specifically designed, the use of totally polyester fabric compromises a number of essential mechanical properties. The biggest danger is that in a conventional weave, a polyester weft can cause low transverse elasticity, which reduces troughability, impact resistance and also causes tracking issues. However, it is important to add that the use of all polyester (EE) fabrics does play an important role in certain applications such as sawmill belts for example.

Out of sight, out of mind. Looks fine on the outside but what is happening inside?

Not what they claim - some belts are supplied totally polyester (EE) fabric plies in a carcass declared as being an EP (polyester/nylon) carcass

Unfortunately, an increasingly common deception employed by less scrupulous manufacturers, traders and importers is to supply belts that have totally polyester (EE) fabric plies in a carcass that is claimed to be an EP (polyester/nylon mix) construction. As a result, although the longitudinal strands of the fabric may be sufficient to achieve the required tensile strength, rip and tear resistance are reduced, and elongation (stretch) is lowered. This in turn can cause problems with transition distances and a general inability to accommodate the contours of the conveyor and its drums and pulleys, ultimately lead to premature failure.

There can be enormous differences in the strength and quality of the fabric and a corresponding difference in their cost.

The sole reason for this deception is that polyester costs some 30% less than nylon. This is significant because, after rubber, the fabric is the highest cost component. Consequently, using lower cost polyester fabric is a big help towards achieving the perception of a lower ‘like for like’ price.

There can be enormous differences in the strength and quality of the fabric and a corresponding difference in cost. Although they may be the same specification on paper, the strength under load both longitudinally and transversely can be inconsistent and prone to steering and handling problems. Yet again, this is almost entirely influenced by whether the belt manufacturer is at the ‘quality end’ of the market or the ‘cut-throat’ end.

CARCASS FAILURE CAUSED BY POOR ADHESION

The term ‘adhesion’ relates to the adhesive bond between the inner ply layers to adjoining layers and between the surfaces of the outer plies and the rubber covers. It is defined as the force required to separate adjoining plies and/or between the plies and the outer covers. The adhesion properties of a belt are fundamental to its durability, functionality and structural integrity and determines a belt’s ability to trough and carry heavy loads without the risk of ply separation. The continual flexing over pulleys and drums creates stress so it is essential that the belt has adequate ply adhesion to withstand this without delaminating, which is where the various layers separate, and the belt literally falls apart.

Delamination - layers separate and the belt literally falls apart.

Adhesion also has an enormous impact on the reliability of splice joints because insufficient adhesion compromises the strength and longevity of the joint. Unsurprisingly, the root cause is the use of low-grade raw materials such as polymers, crucial fillers such as carbon black, vulcanizing agents, plasticisers, resins and curatives. Other causes include overheating or overcooking during the vulcanization process and the use of cheap bulking fillers such as chalk or clay.

STRETCHING THE LIMITS

Elongation is an often misunderstood technical term applied to rubber conveyor belts. It is best defined as the change in length (stretch) of a belt when subjected to tensile stress of which there are three forms - elastic elongation, permanent elongation, and elongation at break. With each tensile stress below break load, the belt is subject to an elongation which, when the stress is relieved, partly recovers (elastic elongation) and partly remains (permanent elongation). The elongation at break is the amount of elongation at the moment the belt breaks. All three forms are effectively determined by the properties engineered into the belt during its manufacture. The primary influence on those properties is the quality, type and weave design of the fabric plies and secondly, the elongation characteristics of the rubber covers.

The elongation of a carcass is critical in determining how a belt will react when subjected to varying stress levels. These stresses change due to system influences such as tension, transitions, vertical and horizontal curves, turnovers, and crowned pulleys. Insufficient elongation is mostly an issue in areas where a multi-ply belt needs to stretch, such as troughing and bending round pulleys for example. It can cause localised tension build-up, which can have an especially negative effect on the splice joint. It can also lead to shear stresses that may in turn cause delamination issues. Conversely, too much elongation can result in insufficient tension, which can lead to premature wear and tear.

SPECIALIST CARCASS FABRICS

Traditionally, single and dual ply carcass constructions are used for light applications. However, nowadays it is worth exploring special carcass constructions for medium to heavy duty applications, such as those used by Fenner Dunlop. Since the hugely ground-breaking introduction of their single and dual-ply UsFlex belt more than two decades ago, they have continued to develop the concept, known as the X Series range. Despite being thinner and lighter, they are successfully replacing traditional, thicker, heavier multi-layered belts because they are much more robust and resistant to damage and much less prone to the problems so often found in their multi-ply counterparts.

In theory, a higher number of inner plies should result in a stronger belt. However, the greatest influence on the strength and other essential physical properties of a conveyor belt is the design and quality of the ply material used to create the carcass. Fenner Dunlop have their own fabric weaving facility in the USA. It is here that they have developed a range of unique super-strength fabrics for single-ply belts (Ultra X and Nova X) and the longer established single and dual-ply UsFlex belts for more extreme working conditions. The carcasses possess a longitudinal rip resistance that is more than 500% greater than multi-ply belts of equivalent rating and up to 300% greater impact resistance compared to conventional belting.

The whole working principle of single and dual-ply belts firstly centres on using very high quality, super-strength fibres and

Elongation at break is the amount of elongation at the moment the belt breaks.

Inside Fenner Dunlop's fabric weaving facility in the USA.

Unique weave designs using high quality, super-strength individual fibres and yarns stops rips and tears in their tracks. (Image courtesy of Fenner Dunlop).

yarns followed by the design of the weave pattern, which is critical and unique to Fenner Dunlop. Ultra X features a specially woven "Crimped warp" carcass, combining crimped polyester warp yarns with strong binder and filler yarns, while the higher tensile strength Nova-X (available in North America and coming soon to Europe) uses an even stronger crimped warp fabric with binder yarns to lock the carcass. Both types provide very high rip, tear, and impact resistance under load. The heavier duty UsFlex employs a "Straight warp" fabric carcass, made of high-tenacity polyester fibres protected by polyamide weft lines.

What they all have in common is longitudinal strands lengthwise and heavy strands running crosswise that are completely straight in both directions and not interlocked as in conventional fabric. This allows the weft to float free from the warp creating a shock absorber effect by dissipating impact energy over a larger area. This allows the belt to withstand the kind of punishment that would destroy a normal multi-ply belt. Arguably an even more significant advantage is the ability to resist rip and tear damage. When penetrated and being pulled through a trapped object such as a sharp rock, the unique weave design allows the strands to gather in a bundle that can eventually become strong enough to stop the belt or even expel the object causing the damage.

CONCLUSION

Whether single, dual or multi-ply, there is no doubt that the quality of the carcass is of equal importance to the quality of the rubber covers. They are inter-dependant and in both cases, when a low selling price is the driver then reliability, longevity, productivity and running costs all suffer.

Leslie David

ABOUT THE AUTHOR

After spending 23 years in logistics management, **Leslie David** has specialised in conveyor belting for over 19 years. During that time, he has become one of the most published authors on conveyor belt technology in the world.

Maximizing Efficiency and Longevity: The Role of Wear Parts in the Mining Industry

INTRODUCTION

As far back as the1980s wear problems in the mining industry were viewed in two ways, by the engineer who had to solve them as a **nightmare**, and by the salesperson of wear resistant materials as a dream. The industry is a substantial market for wear resistant materials and there has been constant pressure by manufactures of a wide variety of products to capture a share of today's market. The rewards for doing so can be large and can provide a base from which a small operation can expand. The engineers in the industry however found themselves faced with an apparently unending stream of trade names, treatments and materials and often had little information on which to base a judgment about the product on offer. He was regaled with facts that prove the product has performed well in some pieces of equipment of which he may never have heard, in another industry, or has done wonders for mine productivity worldwide.

Take for example hardfaced wearplate in Uk coal mines used in a wide variety of applications that during the 1980s had only one supplier to British Coal but as a market developed other manufactures became keen to supply. The profusion of these firms prompted the question "Are all these firms supplying the same thing?" This led to investigations in the quality and wear resistance from a number of suppliers in which wide variations were found and revealed that few of them possessed the desired structure required. One can imagine that this predicament in the mining industry worldwide and the supply of various wear resistant materials was truly an engineer's nightmare

MOVING ON

Today's engineers are shaping the future of wear parts in mining by balancing durability, efficiency, and sustainability. Investing in smart technologies, sustainable materials, and predictive analytics ensures reduced downtime, lower environmental impact, and a more cost-effective approach to equipment maintenance. As mining operations continue evolving toward greener solutions, wear parts will remain pivotal in shaping the industry's sustainable future.

Trevor Barratt MD looks at the distinct types of wear problems that can occur in everyday mining operations and looks at the latest technological advances.

TYPES OF WEAR PARTS

Although definitions are given in this section of six types of wear mechanism, in many applications more than one mechanism may be operative. Where this is so synergistic affects may occur i.e. the total amount may exceed the sum of the amounts of wear produced by the mechanisms individually.

Corrosion is not a wear mechanism under the definition given at the beginning of this paper because though it satisfied the requirements for gradualness in material removal, it does not satisfy the requirements of mechanical action. However, if corrosion is not a wear mechanism it is certainly a close companion of wear and in mining it is often found working hand in hand with wear. Indeed, synergistic effects between corrosion and wear mechanisms of several types are likely to be more significant than synergism between different wear mechanisms.

1. ABRASIVE WEAR

There are three subdivisions of abrasive wear.

(a) Two- body low stress.

The ploughing action of abrasive material sliding over the surface at low loads results in the removal of wear debris without reducing the size of the abrasive.

(b) Two-body, high stress with impact.
The high stress action with the effect of impact results in gouging, deformation and fracture.

THREE-BODY, HIGH STRESS GRINDING

A Three abrasive solid, found between two surface is in relative motion wears away the surface by gouging, deformation and fracture.

One of the principal requirements of metallic materials to resist abrasive wear is hardness. Earlier tests have shown that when the hardness of the material being abraded reaches 80% of that of the abrasive wear rate falls sharply.

Bulk hardness is, however, not the whole of the story. Evidence suggests that work hardening can take place during abrasive wear on both micro and macro scales, so that the hardness of the material after work hardening is important. In situations involving impact in high stress the 11 to 14% manganese steels with a high propensity for work hardening perform well. Recognition has to be made of the importance of the manner of achieving hardness. In the high carbon, high chromium cast irons and hard facings hardness can be achieved by the presence of hard carbides. The softer matrix can be worn away by abrasives that are sufficiently small, resulting in a much higher wear rate than expected. Resilience is also important in rubbers and plastics demonstrated by their increasing use in worldwide mining applications.

2. ADHESIVE WEAR

This mechanism involves two surfaces sliding over each other under load. Welding of contacting asperities is followed by the breakage of the junctions and the subsequent removal of wear particles from the surface. Scuffing is a form of adhesive wear. The term scuffing is used in connection with lubricated surfaces where the lubricant film has broken down.

In addition to scuffing other terms such as galling and pickup were used to describe special types of adhesive wear. It is recognised that steels have a greater tendency to adhesive wear when sliding against each other if their chemical compositions are all similar. Stainless steels sliding against themselves are well known for the tendency to pick up.

3. PARTICULATE EROSION

Particles of abrasive solid, carried in a gas or fluid stream, impinge upon a surface causing localised wear. The angle of impingement is important. Ceramics, for example, work well when impingement angles are low (less than 10%) but poorly at high impingement angles. Microstructure is an important factor in the ability of materials to resist particulate erosion.

4. CAVITATION EROSION

The formation of vapour bubbles in a liquid when the pressure in the liquid falls below its vapour pressure is known as cavitation. The collapse of these vapour bubbles close to surfaces may cause material to be removed from the surfaces. This material removed is called cavitation erosion. Water droplet erosion is a similar removal process occurring when droplets of water impinge at high speed on surfaces.

Flow erosion is a phenomenon often seen in hydraulic systems in association with cavitation erosion. It appears to be a combination of corrosion and particle erosion. Cavitation take place more readily in water containing fluids and in mineral oils because of the high vapour pressure of the water. Invert emulsions appear to suffer less from cavitation than might be expected from their water content. The reason may lie in the encapsulation of the water as small droplets. Materials with high resilience, such as rubbers and plastics have been found to have high resistant to cavitation erosion. In metals cavitation erosion resistance increases with hardness, but microstructure is important, and hardness cannot be used as an absolute guide to erosion resistance.

5. FRETTING-SMALL AMPLITUDE SLIDING

Fretting results from a small amplitude oscillation, say less than 200 micrometres, between contacting surfaces. It occurs over a wind range frequencies and the production of substantial amounts of oxidised wear debris(cocoa) is a characteristic of the process. Fretting is possible a special case of adhesive wear in which the wear debris is kept in the contact area and may contribute to later material removal. Investigations have shown the fatigue cracking starts more readily from areas of fretting damage than would otherwise be the case.

6. CONTACT FATIGUE

Contact fatigue occurs as a result of cyclic pressures between contacting surfaces.

Cracks are generated either at or below the surface and the propagation of these cracks results in eventual material removal (pitting). The phenomenon is found most often in roller bearings in gears. The use of cleaner steels has enabled bearing load capacity ratings to be raised over the years and the recognition of the importance of the various regimes of lubrication has allowed bearing companies to provide guidance of the effect of this aspect of service environment on bearing life. As stated earlier the influence of corrosion on wear rates can be large. In contact fatigue the effect of small amounts of water i.e. less than 1% on the fatigue process is to shorten the time to produce pitting by orders of magnitude

Wear parts vary based on equipment type and operational requirements. Some key categories include:

- **Crusher Liners:** Protect crushers from excessive wear during ore processing.
- **Drill Bits and Cutting Tools:** Used for drilling, tunnelling, and excavation, requiring high resistance to abrasion.
- **Conveyor Belts and Rollers:** Essential for material transportation, often reinforced with wear-resistant coatings.
- **Excavator and Loader Buckets:** Designed with reinforced edges to handle heavy loads and resist impact damage.
- **Materials Used in Wear Parts**
- Materials play a crucial role in wear resistance, with common choices including:

- **High-Strength Steel:** Offers durability and impact resistance.
- **Tungsten Carbide:** Used in drill bits for superior hardness.
- **Ceramic Composites:** Provide exceptional abrasion resistance for grinding applications.
- **Rubber and Polyurethane:** Used for shock absorption and wear protection in conveyor systems.

FACTORS AFFECTING MATERIALS SELECTION

Wear resistance is rarely the sole function of a material in an application. In most circumstances involved in wear, materials from which components are produced have to possess other attributes such as structural strength, weldability, formability and corrosion resistance. These required attributes combined with the functional limitations of the component to restrict the choice of materials which will be suitable for the application.

A further restriction on materials choice is imposed by the requirement of maximum cost effectiveness.

The final question “Will the material give the required life” is the most crucial one. To answer it requires a detailed knowledge of the effects of the various environmental parameters, load, sliding speed, temperature, abrasivity and so on, on the wear life of the material concerned.

PRICING

Several factors influence the pricing of mining wear parts, including:

- **Material Composition** – High-quality materials like Hardox® steel or tungsten carbide increase durability but also raise costs.
- **Manufacturing Process** – Advanced techniques such as precision casting or heat treatment add to production expenses.
- **Supply Chain & Logistics** – Global disruptions, transportation costs, and lead times can significantly impact pricing.
- **Wear Resistance & Longevity** – Parts designed for extended wear life often come at a premium due to specialized coatings or reinforced alloys.
- **Customization & Specifications** – Tailored solutions for specific mining applications tend to be more expensive than standard off-the-shelf components.
- **Market Demand & Availability** – Fluctuations in commodity prices and mining activity influence demand, affecting costs.
- **Supplier Reputation & Brand** – Established brands with proven reliability may charge higher prices for their expertise and quality assurance.

ADVANCES IN WEAR PART TECHNOLOGY

- Recent innovations aim to enhance longevity and performance:
- **Nanotechnology Coatings:** Improve wear resistance and reduce friction.
- **Composite Materials:** Combine metal and ceramics for optimized durability.
- **Smart Wear Monitoring:** Sensors track wear rates to optimize maintenance schedules.

SUSTAINABILITY AND RECYCLING

- Mining companies are focusing on sustainable practices, including wear part recycling and eco-friendly materials to reduce environmental impact.

CONCLUSION

- Wear parts are indispensable in mining, influencing efficiency, cost management, and equipment lifespan. Investing in high-quality wear parts and embracing technological advancements ensures sustained productivity in modern mining operations.

The Dominance of Surface Mining

Any countries economic growth and ability to meet its population's daily needs are significantly reliant on the mining sector. Planners and policymakers have long recognized mining's crucial role in the nation's economic and developmental model. To support this, various regulations were enacted, and extensive efforts were made to produce vast quantities of ores, minerals, and waste material through surface mining. The focus for most countries is on safely and economically producing ores and minerals using new technologies, while also considering global pricing and ensuring harmony with all stakeholders for sustainable development, particularly through innovations in mining methods.

THE DOMINANCE OF SURFACE MINING

Surface mining is the primary method used in many countries for extracting a majority of coal, lignite, iron ore, limestone, dolomite, bauxite, copper, lead, zinc, and other minerals. This method has been instrumental in meeting the increasing demand for various minerals. Historically, coal extraction was dominated by underground methods until the late 1980s, when there was a significant shift towards large-scale surface mine development.

Currently, surface mines account for over 80% of coal production and 100% of lignite production in certain countries. Similarly, in the non-fuel sector, most iron ore, limestone, dolomite, bauxite, and barite are produced exclusively from surface mines. A smaller proportion of copper, chrome ore, lead, zinc, and manganese also come from surface mines, with only a small amount from underground operations.

The expansion of surface mining has been supported by several key factors:

- Extensive exploration and detailed planning of ore bodies.
- Massive investment in mining machinery and extraction systems.
- Investment in research and development to safely achieve higher percentage recovery.
- Commissioning of state-of-the-art mineral processing systems.
- Plans and programs focused on maintaining ecological balance to mitigate air, water, and land degradation caused by mining.
- Acceptable Resettlement & Rehabilitation (R&R) policies for populations affected by mining activities.
- Development of infrastructure to handle the movement of final products to consumer industries or port facilities for exports.

MINE PLANNING AND INFRASTRUCTURE

Ore body evaluation, geostatistical reserve estimation, and **modelling** are crucial for the overall economics of any mine. Computer software packages play a vital role in assisting mine planners and geoscientists with detailed and accurate short-term and long-term mine planning. In many countries, the latest software has been adopted, and users at the mine level have been trained to account for local site conditions in greater detail.

Optimum infrastructure planning involves multiple operators sharing land and other resources. The feasibility of mining common barriers should be explored. Infrastructure layouts must be planned to avoid blocking resources or hindering their exploitation. The infrastructure should align with the Master Planning of the entire area, considering mines operated by different companies.

TECHNOLOGY AND METHODS OF WORK

For opencast mining, the application of large-capacity shovel-dumper systems and surface miners needs to

be evaluated. For shovel-dumper systems, equipment configuration should be standardized to 3 or 4 modules. Although the largest size of dragline utilized has remained unchanged for two decades, it is essential to consider global prevalent sizes and technologies during the planning phase.

Automation, electrification, digitalization, and Artificial Intelligence (AI) are transforming surface mining, an industry traditionally defined by massive equipment and bulk earthmoving. Technological innovation is reshaping surface operations from drilling to hauling. The drive for greater efficiency, safety, and sustainability is pushing surface mining into a new era, where intelligence is prioritized over sheer horsepower. This shift means that digital fluency and data-driven thinking are becoming essential skills in a field once defined by physical intensity.

Autonomous equipment is no longer experimental; it is operational. Driverless haul trucks, semi-autonomous drills, and remotely operated dozers are becoming integral parts of mining fleets. These systems not only reduce human exposure to hazardous environments but also optimize cycle times, fuel usage, and maintenance schedules. Digital technology allows mining teams to create real-time, dynamic models of their entire operations.

Furthermore, as the mining industry faces increasing pressure to decarbonize, electrification is moving from aspiration to application. Battery-electric and hybrid equipment – such as haul trucks and drills – are being deployed to reduce diesel consumption, lower emissions, and meet ESG targets. Finally, integrated data platforms are revolutionizing how mines operate, connect, and optimize. With sensors embedded throughout operations – from blast holes to processing plants – AI and machine learning (ML) models can now predict outcomes, detect anomalies, and recommend actions in real-time. For example, AI can optimize blasting outcomes, reduce oversize material, and improve fragmentation.

Sandvik is shaping the future of autonomous surface drilling with the launch of its AutoMine Surface Fleet.

The solution enables operators to manage more than 15 Sandvik i-series drill rigs from any connected location. Built to boost productivity and reduce downtime, particularly during shift changes, the system provides a flexible and integrated automation solution.

“The system is fully compatible with the AutoMine Universal Station, allowing the operation of both boom and rotary drills even in challenging environments, such as rock and weather conditions,” Sandvik mining surface automation product line manager Severi Eerola said.

“This ensures every shift can be run at optimal performance, regardless of the conditions, by providing a fully integrated solution that allows mining operations to run continuously and efficiently, even during blast breaks.”

The system includes FleetFlex functionality, allowing seamless transfer of drill rigs between stations. This gives operators greater control over larger fleets with improved efficiency, whether operating from on-site or remote city-based control centres.

The groundbreaking fleet also integrates AutoCycle capabilities for near-continuous operation with minimal human input. Tasks such as stabilising, collaring, drilling, pipe handling, hole finishing and tramming are automated for safe and efficient drilling.

Operators can manage individual rigs or the entire bench, benefiting from advanced positioning, obstacle detection and automated drilling features. Extensive trials at Boliden's Kevitsa open-pit mine in northern Finland have demonstrated the technology's value in complex geological conditions.

"The AutoMine Surface Fleet solution has enabled us to optimise our operations under these demanding conditions," Boliden Kevitsa drilling development manager Juha Ranta said.

"The ability for operators to seamlessly switch to remote control, along with the strong aftermarket support from Sandvik, has been instrumental in maintaining high performance."

SUSTAINABILITY FOCUS

As digital transformation accelerates, there is a growing emphasis on environmental accountability. Mines are adopting real-time monitoring systems for dust, vibration, and water quality, while leveraging drones and satellite imagery for progressive rehabilitation and compliance tracking. These tools support regulatory reporting and help build trust with surrounding communities and stakeholders, particularly First Nations. Surface mining is becoming faster, smarter, and cleaner. As operations become increasingly data-centric and automated, the role of human expertise is evolving from direct control to strategic oversight and systems integration. Success in this new landscape will go to those who embrace innovation—not just in tools, but in mindset.

The surface mining industry is shifting towards more sustainable practices, with the concept of green mining gaining prominence. This emphasizes methods that reduce carbon emissions and minimize ecological impact. Techniques like surface miners eliminate the need for traditional drilling and blasting, which can disrupt surrounding ecosystems.

Additionally, many companies are investing in renewable energy sources to power their operations, transitioning to solar or wind energy to significantly lower their carbon footprints and reduce operational costs. The implementation of sustainable water management practices is another critical trend; treated mine water is now being reused for irrigation and industrial purposes, promoting resource conservation.

MARKET GROWTH, COLLABORATION, AND INNOVATION

The surface mining market is projected to grow steadily, with the market size expected to increase from $28.39 billion in 2023 to $35.2 billion by 2028. This growth is driven by rising demand for minerals and natural resources, fuelled by global urbanization and infrastructure development projects.

To thrive in this evolving landscape, collaboration between mining companies and technology providers is crucial. By working together on digital transformation initiatives, companies can leverage innovative solutions that enhance productivity while ensuring safety and sustainability.

In conclusion, surface mining is undergoing a significant transformation driven by technological advancements and a strong commitment to sustainability. As the industry embraces these trends, it will not only meet the growing demand for essential resources but also pave the way for a more responsible approach to resource extraction. By prioritizing innovation and environmental stewardship, surface mining can continue to play a vital role in supporting global economic growth while protecting our planet for future generations.

Critical minerals in the energy transition: What are they and what is their future

The transition to renewable energy sources relies heavily on critical minerals, which are necessary for technologies such as batteries and solar panels. However, the extraction and processing of these minerals pose significant environmental and social challenges. As the global commitment to clean energy accelerates, the foundation of tomorrow's energy systems demands a transformative approach to sourcing, refining and reusing materials.

Critical minerals, indispensable for technologies such as solar panels, wind turbines and electric vehicle batteries, are at the heart of this transition. However, their extraction, supply chain management and life cycle require a paradigm shift to meet growing global energy goals while preserving environmental and social integrity.

This article explores the key challenges associated with the extraction of critical minerals, including carbon emissions, social and biodiversity impacts and circularity gaps. It also examines possible solutions to mitigate these problems and explores three strategic approaches to minimize the impact of critical minerals: redesigning products and business models and introducing sound policies.

THE BACKBONE OF THE ENERGY TRANSITION: CRITICAL MINERALS

This energy transformation requires mining engineering experts and decision makers to rethink traditional methods and embrace innovation. Advanced economies must provide strategic support to communities that depend on mineral extraction, enabling sustainable integration into diversified economies.

In this context, critical minerals are more than resources; they are strategic enablers of a cleaner, more sustainable future. By promoting policies that incentivize innovation and sustainability, stakeholders can shape an ecosystem that protects natural resources while meeting the unprecedented demand for critical minerals; this will determine the success of the energy transition and ensure its benefits for future generations.

The International Energy Agency (IEA) highlights in a recent report that the market for critical minerals is growing at an unprecedented rate due to increased investment driven by demand for clean energy. However, it warns that more work is needed to ensure a diversified and sustainable supply of these minerals to support the energy transition. According to the report, the market for essential minerals for technologies such as electric vehicles, wind turbines and solar panels has doubled in the last five years.

At the same time, investments in alternative sourcing, improved recycling capabilities and energy-efficient technologies must be prioritized to ensure supply chain resilience and minimize waste. Mining engineers, economists, and policy makers must act decisively, combining their expertise to balance the technical, economic and social dimensions of this challenge. Only then can the full potential of critical minerals be realized, driving progress and protecting people and the planet.

THE CHALLENGE OF CARBON EMISSIONS FROM MINING CRITICAL MINERALS

The mining of critical minerals, essential for clean and renewable technologies, faces a problem: their high

Critical minerals: Lithium, nickel, cobalt, manganese and graphite.

energy consumption contributes significantly to carbon emissions. Despite their key role in the energy transition, mining operations often rely on fossil fuels, which contrasts with global decarbonization goals.

Mining companies have the capital to lead the shift to sustainable practices. The adoption of solutions such as green hydrogen for heavy machinery or process electrification has proven viable. However, these initiatives need to be scaled up quickly to have a real impact on reducing emissions throughout the value chain.

In addition, the development of more energy-efficient technologies is imperative. Innovations such as advanced sensors, automation, and energy recovery systems could transform mining operations, optimizing their sustainability without compromising their productivity. Mining has the potential to be part of the climate solution but requires a strong commitment to clean and resilient technologies.

NEW LITHIUM SALTS: THE FUTURE OF MORE EFFICIENT BATTERIES

The development of new lithium salts represents a key opportunity to improve the capacity and lifetime of modern batteries. While battery research has mainly focused on active cathode materials or electrolyte matrices, the potential of lithium salts remains an unexplored field. This component is crucial to ensure ionic conductivity and electrochemical stability, which are essential to meet the growing demands of energy storage.

Currently, salts such as lithium hexafluorophosphate (LiPF6) and lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) are used in lithium-ion batteries: they dominate the market in liquid and polymer electrolytes, respectively. However, their performance is not without limitations, especially in terms of thermal stability and long-term durability. The search for alternatives with more stable and less corrosive anions could transform battery design, enabling superior cyclability and less degradation of internal components.

Innovating in lithium salt chemistry not only impacts battery efficiency, but also sustainability. Optimized salts can reduce the need for frequent replacement, reducing the environmental impact associated with battery production and disposal. This approach, along with advances in other areas, positions the development of new lithium salts as a fundamental pillar in the evolution of energy storage technologies.

BIODIVERSITY AND SOCIAL IMPACTS OF CRITICAL MINERALS

Mining activities can lead to water depletion, land use change and pollution, causing loss of biodiversity and negatively affecting natural resources. These environmental impacts affect the well-being of local communities and may infringe on the rights of indigenous peoples, as a significant portion of critical materials are located near indigenous lands.

In addition, the development of infrastructure for mining may lead to increased poaching, illegal logging and social unrest.

Gaps in circularity

Current efforts to recycle critical minerals are insufficient. Battery collection and recycling and renewable infrastructure face challenges due to material design and transportation distances.

Often, recyclable materials are shipped overseas, where regulations may not adequately protect those who manage the waste, or the nearby communities affected by its disposal.

Aerial view of brine ponds and processing areas of the lithium mine.

Proposed solutions

Investment in renewable energy

Mining companies must invest in renewable energy sources to power their operations, reducing the carbon emissions associated with mineral extraction. Technologies such as green hydrogen can play a critical role in this transition.

Responsible sourcing and regulation

Companies should adopt sourcing practices that minimize impacts on people and biodiversity. This includes respecting the rights of local people and ensuring that mining activities do not damage local ecosystems. Policies that drive responsible sourcing will help shape future business practices.

Expanding recycling efforts

Recycling is essential to reduce reliance on new mining activities. It can reduce the need for new mines by 25-40% by 2050 if scaled up effectively. Investing in domestic recycling infrastructure can improve supply chain resilience and reduce environmental impacts associated with mining.

Implementation of circular economy principles

Adopting circular economy models can significantly reduce waste and extend the life of materials to their maximum value. This approach involves designing products for recyclability and ensuring that materials are recycled back into the economy.

Product redesign to reduce mineral demand

Innovative product design is critical to reducing dependence on high-demand minerals. By focusing on energy efficiency and alternative materials, industries can mitigate the environmental and social impacts associated with mineral extraction.

Energy-efficient technologies: The design of lighter batteries reduces the need for energy-intensive minerals. For example, phosphate, lithium iron and sodium batteries are being developed to replace nickel and cobalt, which are more difficult to obtain and have more significant environmental impacts.

Mining product redesign: Companies that have leveraged existing infrastructure to develop products such as mineral sand from iron ore by-products. This innovation addresses the rising costs of mining waste, which is projected to exceed $1.6 trillion over the next three decades.

Reimagining business models

Adopting circular economy principles can transform business models, reducing waste and improving sustainability.

Companies worldwide have incorporated circular design from the outset, creating ecosystems that use materials that are often wasted. This approach not only reduces waste but also opens up new market opportunities.

With the rise of electric vehicles, battery recycling is becoming increasingly important. International companies are partnering with automakers to recycle valuable materials, reducing costs and emissions.

STRENGTHENING POLICIES FOR SUSTAINABLE PRACTICES

Sound policies are essential to reduce demand and increase supply through sustainable practices.

Energy efficiency policies: Encouraging the development of smart cities can reduce energy consumption and demand for critical minerals. Policies that promote public transportation and walkable neighbourhoods can significantly reduce transportation emissions.

Incentives for recycling: Policies that incentivize recycling can improve the supply of critical minerals while reducing carbon emissions. The EU battery regulation aims to increase material recovery and reduce recycling costs through manufacturing standards.

Addressing the impact of critical minerals requires a multifaceted approach that includes innovative product design, renewed business models and strengthened policies. By focusing on these strategies, industries can ensure a more equitable and sustainable energy transition while minimizing environmental and social impacts.

Innovative battery technologies play a crucial role in reducing demand for critical minerals by introducing new designs and chemistries that use fewer critical minerals or replace them with more abundant materials. These are the key ways in which these innovations contribute to minimizing dependence on critical minerals:

Diversification of battery chemistry

Alternative chemistries: The development of battery chemistries that reduce or eliminate the need for scarce and environmentally challenging minerals is a significant advance.

For example, lithium iron phosphate (LFP) and sodium-ion batteries represent an alternative solution to traditional lithium-ion batteries that rely heavily on cobalt and nickel. These alternatives help mitigate the supply risks associated with these critical minerals.

Reduced cobalt use: Innovations in battery design have led to a shift toward lower cobalt chemistries. This transition helps limit the growth in demand for cobalt, which is often associated with ethical and environmental concerns.

Efficiency and material substitution

Reducing material use intensity: Technological advances have enabled significant reductions in material use intensity for clean energy technologies. For example, there have been 40-50% reductions in the use of silver and silicon in solar cells over the last decade, demonstrating how innovation can reduce material requirements.

Substitution with abundant materials: Innovations such as direct extraction of lithium from saltwater brines and the use of sodium-ion batteries offer avenues for substituting more abundant materials for those that are less available or more difficult to obtain sustainably.

Direct lithium extraction is a process by which lithium is separated from the other components of the brine (water in salt concentration in the salt flats) so that it can be removed more easily, without having to use large evaporation pools.

CONCLUSIONS

Promoting sustainable practices is key to the responsible supply of critical minerals: Embracing the circular economy, encouraging battery technology innovation and establishing supportive policies can ensure stable access to these essential resources while minimizing environmental and social impacts.

A holistic approach ensures sustainability in the energy transition: Reducing emissions in mining, optimizing recycling and mitigating impacts on biodiversity are key pillars to meet the growing demand for critical minerals in the transition to clean energy technologies.

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NEWS, PLANT AND EQUIPMENT

Vale's new CEO aims to make Brazilian miner the world's biggest

The new head of Vale has laid out one of the Brazilian company's most ambitious goals — becoming the world's biggest metals producer by market capitalisation.

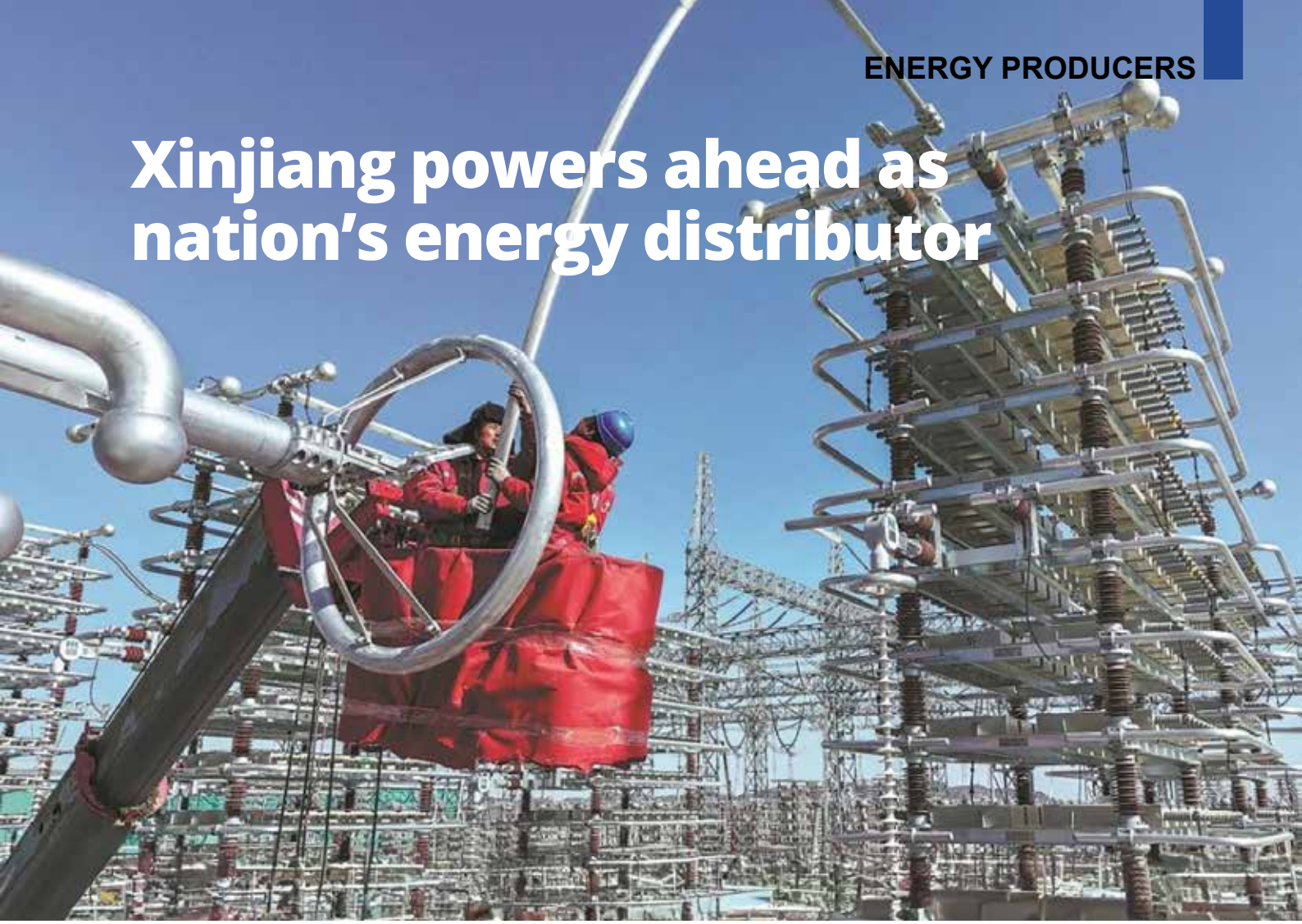
"It has to be the biggest mining company in the world because we are sitting on the biggest mining endowment in the world," CEO Gustavo Pimenta said recently at a business event in Sao Paulo. "We need to unlock the value of this company."

Pimenta, who took over as CEO in October, has a tall order to eclipse larger rivals including BHP Group and Rio Tinto Group. Vale's market capitalization is $43.9-billion, close to a third of BHP's market value and less than half of Rio Tinto. He said that Vale was ranked second for market value a decade ago. That changed when two deadly mining disasters and a plunge in iron-ore production eroded investor sentiment in the stock.

Pimenta told the business crowd that he aims to improve Vale's market value through operational stability, safety improvements and further development of its mining assets. He also said Vale's 2030 target for iron-ore annual output should secure the company's rank as the world's biggest producer of the steelmaking ingredient.

"We want to reach 360-million tons, regaining the position we should never have lost as the world's largest iron ore mining company," he said. "We are well on the way of regaining this position."

Xinjiang powers ahead as nation's energy distributor



Boasting China's largest reserves of coal and solar resources and the second-largest wind energy potential, the Xinjiang Uygur autonomous region has undergone a remarkable metamorphosis into a major national energy producer and domestic electricity provider.

Under the 14th Five-Year Plan (2021-25), Xinjiang has been designated as a national base for wind and solar energy, coal production, oil and gas reserves, and a key electricity transmission corridor.

By the end of 2024, the region had transmitted more than 860 billion kilowatt-hours of electricity to other provincial-level regions – the equivalent of 260.15 million metric tons of coal – helping the recipient area reduce 702.41 million tons of carbon dioxide emissions and 2.21 million tons of sulphur dioxide emissions.

Xinjiang's development comes at a crucial time. Eastern coastal regions face growing electricity shortages coupled with land constraints and environmental pressures that limit further coal power expansion.

Meanwhile, the rapid growth of artificial intelligence has triggered a substantial surge in electricity demand. As AI systems grow more sophisticated, their computational requirements have escalated exponentially, leading to massive energy consumption, particularly from power-hungry data centres running complex machine learning algorithms and large language models.

While Xinjiang's energy riches and rising demand from coastal areas have made it destined to become a key power supplier, the region's progress has been a gradual process, built on years of energy sector investment and construction, and the work of diligent professionals.

SUN, WIND AND WATTS

In Ruoqiang county, Bayingolin Mongolian autonomous prefecture, the construction of a large-scale comprehensive power generation base, with total investment of 71.8 billion yuan ($10 billion), is advancing according to plan.

The base has a planned installed capacity of nearly 19 million kilowatts, comprised of 4 million kW of wind power, 8.5 million kW of photovoltaic solar, and 3.96 million kW of thermal backup, supported by about 5 million kW of energy storage. Construction began on Sept 28, 2024.

Wang Liang, the on-site project manager of the China Three Gorges Corporation's Xinjiang branch, is in charge of building the base.

"Once the power generation base goes into operation, over 60% of its electricity generation will come from renewable green energy sources, and the utilization rate of new energy will exceed 90%," Wang said.

The base will bring a range of benefits to local development. According to a support plan for industries, the corporation has signed agreements with several companies to set up factories for development of industrial clusters and to boost local employment.

A worker installs a spare rectifier transformer bushing at Balikun converter station in Hami, Xinjiang.

Wang Rui, 37, works on the construction project. He was transferred from Beijing to Ruoqiang in March 2024 to carry out preliminary project work with his colleagues.

"When I was a child, my interest in engineering construction was more about natural curiosity. After graduating from Wuhan University with a degree in hydraulic engineering, I decided to integrate my personal career aspirations with national strategic goals. It inspired me to commit myself to the clean energy sector, specializing in hydropower engineering and new energy development," Wang Rui said.

He also worked overseas for many years.

"My main workplace was in Africa, in a place close to the Sahara Desert. The conditions were rather tough. There we taught local residents how to use photovoltaic panels.

"In Ruoqiang, local residents pass on their experience in sand control methods to us and we integrate them into engineering construction," Wang added.

Wang described China's role in the development of the clean energy industry over the past 10 years as "epic".

"From a follower to a leader, China's voice and influence have grown significantly in the clean energy industry," he said. "As of the end of 2024, China's installed capacity of wind and solar power has increased over tenfold compared to a decade ago, with clean energy now accounting for approximately 60% of the nation's total power generation capacity. Notably, about half of the newly added electricity demand is being met by clean energy sources, demonstrating a continuous rise in the green energy of China's energy mix," Wang added.

ENSURING SUPPLY

Solar and wind power are inherently intermittent – their output fluctuates with weather conditions, making supply unpredictable.

On April 28, for example, due to extreme temperature variations, about 55 million people in Spain and Portugal – two countries that source about 80% of their electricity from solar and wind – suffered severe power outages that disrupted public transportation, and bank and internet services.

So how will Xinjiang respond to volatility and make the power grid more resilient?

The Xinjiang Fukang Pumped Storage Power Station of the State Grid Xinyuan Company addresses the issue by storing surplus energy when demand is low, said Lu Jiangang, deputy director of the engineering department. The facility is composed of an upstream reservoir, water conveyance system, underground powerhouse system, ground switch station and a downstream reservoir. The elevation difference between the two reservoirs is approximately 400 meters.

"When electricity demand is low, the plant uses surplus power to pump water from a lower reservoir to an upper reservoir, converting electrical energy into stored energy. When demand peaks, water is released back to the lower

reservoir through turbines, generating electricity," said Lu. Yang Hongtao, chairman of the company, said: "Generally, the station pumps water from the downstream reservoir between 9 am and 3 pm, and generates power between midnight and 7 am, achieving about 80% round-trip efficiency."

The first of its kind in Northwest China, the power station commenced power generation in November 2023. It has a bidirectional and double regulation capacity of 2.4 million kW. As of May 14, the power station had operated nearly 15,000 hours and generated over 2.1 billion kWh of electricity.

Yang said the project was a breakthrough in providing flexible power regulation for the Xinjiang and Northwest China power grids, significantly advancing the transformation of abundant wind and solar resources into economic benefits. The facility plays a vital role in promoting Xinjiang's development of large-scale integrated energy bases that combine wind, solar, hydro, thermal, and energy storage.

"Compared with other storage methods, it boasts large-scale capacity, an exceptional safety record and a long operational lifespan," Yang added.

By balancing supply and demand in real time, the facility not only enhances grid reliability but also supports the large-scale adoption of intermittent renewables like wind and solar by about 2.6 billion kWh annually. That saves 165,000 tons of standard coal consumption and reduces 496,000 tons of carbon dioxide emissions every year.

Lu said the station has six functions: peak shaving, frequency regulation, phase modulation, energy storage, spinning reserve, and black start.

"With the increasing integration of renewable energy capacity in Xinjiang, the demand for flexible power sources will continue to rise. After starting operations, the station has had a significant impact on the safe and stable operation of the power grid and the integration and consumption of renewable energy," Lu said.

However, the role of the power plant transcends grid stabilization. Lu said its construction had helped in the acquiring of valuable building experience and nurtured talent for future projects. Exchange programs and training sessions have since been held to share construction and operational expertise across Xinjiang.

The power station has also improved the fragile local environment – characterized by high altitudes and climate extremes of aridness and cold – through reservoir water evaporation that increases precipitation.

After conducting research, Lu and his colleagues carefully chose seeds and cultivated shrubs sourced from nearby regions, to increase the vegetation coverage and improve the local ecology.

"Two years after the station's operations began, wapitis (elks), foxes and wild boars reappeared and birds have settled in the reservoirs in summer, which is a sign of a better environment," Lu added.

A technician inspects hardware in the valve hall of Balikun converter station in March. (Ding Lei/Xinhua)

ELECTRONS RACING

With growing power production in Xinjiang and rising electricity demand in central and eastern regions of China, long-distance power transmission has become imperative. Located in the barren Changji Hui autonomous prefecture, the Changji converter station – the beginning of the Changji-Guquan Ultra-High-Voltage Direct Current Transmission Project – can transfer power to Xuancheng, Anhui province, within 0.01 second.

The project, which began operating on Sep 26, 2019, stretches through regions of Xinjiang, Gansu, Ningxia, Shaanxi, Henan and Anhui. Designed and constructed domestically, the project is the most technologically advanced ultrahigh voltage transmission project with the world's highest voltage level, the largest transmission capacity, and the longest transmission distance.

"Compared with alternating current, direct current offers constant voltage and direction, lower energy loss and superior efficiency for long-distance transmission," said Wang Hong, head of the Changji converter station. "From Xinjiang to Anhui, power transmission loss through the 3,293-kilometer project is approximately 5%."

When Wang Hong came to Changji to build the station in 2017, there was nothing but Gobi wilderness. Now the area has housing for station staff and the company has planted trees to improve the residential environment.

"In the past we had to commute by long-distance bus rides. Thanks to the new railway to Zhundong, we can reunite with our families in a safer manner," Wang said, adding you can create a "good life" in the tough environment.

Each year, the Changji-Guquan project transmits about 66 billion kWh of electricity annually to East China. This transmission reduces coal transportation by 30.24 million tons, equivalent to 25,000 freight trains (each with 20 carriages) and cuts soot emissions by 24,000 tons, sulphur dioxide by 149,000 tons, and nitrogen oxides by 157,000 tons.

In 2024, the power transmission volume of the project reached 68.3 billion kWh, accounting for approximately half of Xinjiang's total annual power transmission.

It has ranked first among all ultrahigh-voltage projects in China for four consecutive years.

"The station delivery in 2024 is equivalent to 21.27% of Anhui's total power consumption in 2023 and 76 days' worth of the province's power demand," said Wang.

The 38-year-old has been working in ultrahigh-voltage power transmission for 14 years, and this is the third such project he has been involved in.

"During my career, I have witnessed China's power industry develop and progress. I want to work hard, solve problems, and provide people with better power services," he said.

Since its commissioning, the Changji converter station has cumulatively transmitted 340.2 billion kWh of electricity.

"We are developing a new generation of adaptive control algorithms, which could reduce transmission losses from 5% to below 3% in the future," Wang added.

NEWS, PLANT AND EQUIPMENT

UK committed to fresh value-adding mining approach, says Southern African envoy

The UK government is promising Africa a fresh in-Africa value-adding approach to the mining and minerals development it will be going all out to partner and promote.

This promise was spelt out firmly recently by UK trade envoy for Southern Africa Calvin Bailey, MP.

In a zealous keynote address at the London Indaba, Bailey pointed out that many of the crucial minerals vital to key green technologies were particularly present in Southern Africa, his area of interest.

The panel discussion in which Bailey took part was moderated by Herbert Smith Freehills Africa chairperson, South Africa's Peter Leon, and took place at this week's London Indaba, which is organised by South Africa's Resouces4Africa and chaired by mining luminary Bernard Swanepoel.

"Here in the UK, our government is setting out its plans for economic growth to make Britain a clean energy superpower," Bailey revealed.

The industrial strategy, published recently, aims to grow UK sectors such as advanced manufacturing, defence, clean energy and digital technology industries, which rely on critical mineral supplies.

"This is also a central part of the UK's Strategic Defence Review. A secure supply of critical minerals is a key enabler for these visions and strategies.

"This is why this summer, the Department of Business and Trade will publish its new industrial strategy and critical minerals strategy that will drive forward the green industries of the future and help secure our supply chains for the long term.

"The new critical minerals strategy will

refine the UK's approach to its domestic production of critical minerals, including developing our own strengths in midstream processing and recycling.

"It will also support the aims of the UK's new circular economy strategy, driving ambitious reforms to promote recycling and retention of critical minerals,"Bailey told attendees at the event.

He emphasised the UK government's seriousness about optimising its own domestic critical minerals capabilities, "producing more and better in the UK".

This, he said, was why, through the National Wealth Fund, the UK had invested £28-million in the South Crofty tin project, which was being developed by Cornish Minerals, and £24-million in the Cornish Lithium Travelamore project to mine and refine better grade lithium in the UK.

"However, the UK cannot achieve its critical minerals goals alone," Bailey pointed out.

Strategic international collaboration would, he said, be essential to meet the supply needs of UK growth businesses and to promote the global resilience of responsible and sustainable supply chains.

"The new strategy will set out our plans to build targeted growth partnerships with key allies, including resource-rich nations across the Africa continent.

"The strategy will also cement our commitment to multilateral cooperation on critical minerals through fora like the G20 and the Mineral Security Partnership (MSP) forum," Bailey explained.

The promising G20 Summit that South Africa is hosting in Johannesburg on November 22 and 23, will be attended by

Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Türkiye, the UK, and the US.

Through the multilateral G20 and the bilateral MSP engagements, the UK would, Bailey said, seek to deploy UK export finance for overseas projects that supplied critical minerals, as well as for products that contained critical minerals to the UK, fuelling the UK's net-zero energy transition.

The strategy would, Bailey added, also set out how international partners could benefit from the UK's strengths, ranging from the City of London as a global centre for mining finance and commodities training, to Britain's research and development academia and the know-how of the Camborne School of Mines, the British Geological Survey, and a network of universities that developed critical mineral innovations.

The UK, he promised, would go all out to ensure that critical minerals were produced "responsibly, sustainably and transparently, protecting local communities and their environments".

"We want African nations to play a key part in our critical mineral strategy. Many of the critical minerals vital to technologies are present in particularly, my area of interest, Southern Africa.

"We also know that the countries holding significant deposits of critical minerals want a greater share of the value from these resources and the UK will continue to advocate for value addition on African soil.

"UK businesses are investing in Africa. They are actively exploring, producing and refining minerals across Africa.

"Many uphold corporate governance structures that promote transparency and accountability in their operations. I've taken great pride in visiting some of these operations myself and will do in others across the region. These, in turn, help to ensure taxes are paid, skills are transferred, local jobs are created, the environment is protected, and communities are substantially and significantly engaged."

The UK Department of Business and Trade's support of Africa's mining ecosystems formed part of the UK's wider commitment to mutually beneficial partnerships within Africa and in November, the UK Foreign Secretary had announced the government's commitment to "a fresh approach to Africa".

The aim would be to build a long-term strategy to 2035 focusing on strengthening sustainable and inclusive growth and economic transformation, tackling the climate crisis and addressing insecurity.

In the last six months, the UK government had been consulting with potential African partners and later this year, it would set out how Britain would work with African countries.

"This will be a whole-of-government approach which will build long-term, respectful partnerships that deliver on shared UK and African priorities.

"I believe there is great potential for us to create new opportunities for investment into Africa, sharing of UK expertise in the mining and mineral sector and the creation of new value chains that promote economic growth in the UK and in Africa.

"I look forward to working with you on these very exciting opportunities." Bailey enthused.

West African pours first Kiaka gold ahead of schedule

Australia-listed West African Resources has poured first gold at its flagship Kiaka project in Burkina Faso, delivering the milestone ahead of schedule and under budget, as the company progresses toward its ambition of becoming a half-million-ounce-a-year gold producer by 2030.

The maiden pour at Kiaka yielded gold bars weighing 5.7 kg, or 183.3 troy ounces, marking the start of production just three-and-a-half years after the company acquired the project.

"First gold at Kiaka is a major milestone for West African Resources, and a key step towards our target of being a 500 000 oz/y gold producer by 2030," said executive chairperson Richard Hyde. "First gold comes just three-and-a-half years after the acquisition of Kiaka, which is a remarkable achievement by the WAF team."

The company said construction and commissioning activities at the project were substantially complete, with the exception of the high-voltage grid power connection. The processing plant has performed well in early operations, with metallurgical recoveries topping 92% and throughput exceeding expectations.

"With the Kiaka build complete and production ramp-up under way, WAF has realised its strategy of having two long-life, unhedged, low-cost gold production centres

in operation in 2025," Hyde said.

The ramp-up to nameplate capacity is expected to continue through the third quarter. So far, 140 000 t of ore grading 0.7 g/t gold have been processed.

Openpit mining activities are advancing at both Kiaka Main and Kiaka South, with ore stockpiles continuing to build on the run-of-mine pad as mining crews operate double shifts.

West African Resources acknowledged the contributions of its in-house construction team, contractors, consultants, and lenders –Sprott and Coris Bank – for their roles in bringing the project into production.

China's rare earths are flowing again, but not freely

The threat of mass shutdowns across the automotive supply chain is fading as Chinese rare earth magnets begin to flow, though automakers and suppliers say production plans still face uncertainties and a continued risk of shortages.

European suppliers have received enough licences to avoid the widespread disruptions predicted earlier this month but hundreds of permits remain pending, said Nils Poel, head of market affairs at supplier association CLEPA.

The rate of issuance is "accelerating" and has risen to 60% from 25%, he said, but cases where the end users are based in the United States, or where products move through third countries like India, are taking longer or not being prioritised.

"Overall the feeling is that we probably will still have production in July and that the impact will be manageable," he said.

"Maybe here and there a production line will be affected, but we have avoided that for the moment."

Recently, CEO Jim Farley said during an appearance in Colorado that the company has had to shut down factories over the past three weeks because of magnet shortages, without elaborating.

Volkswagen said in a statement to Reuters its supply of rare earth components was stable while rival Stellantis said it had addressed its immediate production concerns.

China restricted exports of seven rare earths and related magnets in April in retaliation for US tariffs.

Three months later there remains huge uncertainty about how it intends to police its opaque and complex export licensing system.

Since the restrictions were imposed, rare earth magnet exports from China have fallen roughly 75%, forcing some automaker production lines to halt in Asia, Europe and the United States.

FROM 'FULL PANIC' TO 'BARE MINIMUM'

The White House said on Thursday it had signed a deal with China to speed up rare earth approvals without providing details. Beijing said hours later both parties had confirmed details of the deal struck in London earlier this month, which was meant to resolve the rare earth issue, and it would process export licences in accordance with the law.

Neither party detailed any changes to the existing export licensing system.

US Treasury Secretary Scott Bessent said in an interview with Fox Business Network on Friday that, under the agreement announced on Thursday, rare earth shipments to the United States from China would be expedited to all companies that have previously received them on a regular basis.

"I am confident now… the magnets will flow," Bessent said. "This is a de-escalation."

Two weeks ago the car industry was in a "full panic," but licence approvals by China have sped up and there is now less threat of a sudden stop, according to an executive at a leading US automotive supplier and a source with knowledge of the supply chain at a major European carmaker. Both asked not to be named because of the sensitivity of the issue.

China is approving the "bare minimum" of critical licences for European firms to avoid production stoppages, a European official told Reuters, also speaking on condition of anonymity.

US magnet maker Dexter Magnetic Technologies, which has defence clients, among others, has received just five of 180 licences since April, CEO Joe Stupfel told Reuters, adding those were intended for non-defence sectors.

"It's an extended delay," he said. "It's 45 days trying to get the paperwork right for the supplier, and then it's 45 more days or so before any licences are granted."

Trends, Drivers, and Outlook

The mining wheel loader market, a crucial component of the heavy machinery sector, was valued at USD 6.5 billion in 2024 and is projected to reach USD 9.8 billion by 2033, demonstrating a robust CAGR of 5.5% from 2026 to 2033. These specialized loaders are indispensable for efficient material extraction and transportation in mining operations, playing a vital role in optimizing productivity, lowering operational expenses, and enhancing safety within demanding environments.

The market's expansion is significantly fuelled by the escalating global need for minerals and metals, driven by ongoing industrialization and infrastructure development worldwide. Underscoring this trend, the U.S. Geological Survey anticipates a global mining industry CAGR of 4.5% from 2023 to 2028, highlighting the increasing reliance on efficient machinery such as wheel loaders.

Gordon Barratt of Mining & Quarry World takes a detailed look at the diverse applications of the mining wheel loader, its future challenges, opportunities and possible restraints in the years ahead.

A **wheel loader**, also known as a **front-end loader**, is a robust piece of heavy equipment designed for efficiently moving and handling bulk materials. Distinguishing itself from crawler loaders that rely on tracks, the wheel loader operates on a wheeled chassis, offering greater speed and agility. Its primary function is to scoop, lift, and transport materials from one point to another, frequently used for loading trucks or distributing materials across expansive job sites.

These versatile machines are adept at managing a broad spectrum of materials, from common dirt, gravel, and sand to more specialized substances like coal. Their operational capabilities extend beyond simple transport to include tasks such as digging, lifting, carrying, creating stockpiles, and even pushing significant volumes of material.

KEY COMPONENTS OF A WHEEL LOADER

1. **Bucket:** The most recognizable part, this large scoop lifts and carries materials. Its size and type can change depending on the loader model and task.

2. **Wheels:** Unlike track loaders, wheel loaders use big tires for speed and agility on solid ground, making them perfect for fast material handling on construction sites, roads, and in mining.

3. **Hydraulic System**: This is the machine's core, powering the bucket's lifting, tilting, and dumping. It uses hydraulic fluid to precisely control the bucket's position.

4. **Arm and Lift Mechanism:** The arm connects the bucket to the chassis, and the lift mechanism controls its movement, raising and lowering the bucket to different heights.

5. **Cab and Controls:** Operators sit in a comfortable cab with controls for the bucket and movement. Modern cabs offer ergonomic controls, climate control, and improved visibility for safer operation.

6. **Engine and Transmission:** High-performance diesel engines power these loaders for heavy-duty tasks. The engine connects to the transmission, allowing efficient movement at various speeds.

TYPES OF WHEEL LOADERS

Wheel loaders come in different sizes to suit various jobs:

1. **Small Wheel Loaders:** Compact and manoeuvrable, these are great for landscaping, roadwork, or light construction in tight spaces.

2. **Medium Wheel Loaders:** Balancing power and mobility, these are versatile for larger construction sites, handling material, excavation, and snow removal.

3. **Large Wheel Loaders:** The biggest and most powerful, these are built for heavy-duty operations like mining, quarrying, and large-scale construction, with huge lifting capacities.

4. **Articulated Wheel Loaders:** These have a central joint that allows the front and rear to pivot separately, giving them superior manoeuvrability in confined or uneven areas, often used in waste handling.

DEVELOPED WITH CUSTOMER NEEDS IN MIND

Before designing the WA700, Komatsu engineers gathered extensive feedback from customers. They identified key concerns such as **safety, cost per tonne produced, CO_2 emissions, maximizing uptime, and operator well-being.** These insights were crucial in developing a powerful machine with advanced features, including exceptional power and stability, substantial load capacity and bucket volume, and extreme durability.

Jo Monsieur, Deputy General Manager Product Marketing at Komatsu Europe, expressed his excitement: “I'm very excited to introduce our WA700-8 in Europe, which offers a perfect match with our 60-tonne rigid dump truck. Without any doubt, it will excite any operator with its performance, large cabin and wealth of safety features. After more than

a decade of development, this reinvented giant is now fully ready to claim its place in quarries across Europe and beyond."

POWERFUL PERFORMANCE

The WA700-8 is equipped with a **robust 578 kW Komatsu engine**, providing the necessary power for optimal efficiency in demanding quarry and mining operations. Its enhanced engine power and torque, combined with a new efficient cooling system and reduced hydraulic losses, result in **fast cycle times and exceptional fuel efficiency**. For improved productivity and operator comfort during V-shape loading, the WA700-8 also features a convenient throttle lock/rpm set function.

REDUCED EMISSIONS

Designed with **environmental sustainability** in mind, the WA700-8 is fully compliant with EU Stage V emissions regulations, making it eligible for all tenders. Additionally, it can use **B20 biodiesels** and is **100% compatible with paraffinic fuels like hydrotreated vegetable oil (HVO)**, significantly reducing CO_2 emissions.

UNCOMPROMISED SAFETY AND OPERATOR COMFORT

Safety is a top priority in the WA700-8's design. It comes standard with an extensive safety package, including **emergency push buttons, certified anchorage and tie-down points, and battery, starter, and hydraulic lockouts**. Full LED lamps are also standard, ensuring excellent visibility and safety during night operations.

To simplify repetitive tasks and reduce operator fatigue, the WA700-8 incorporates **automation features** such as an automatic digging system, semi-automatic approach, and semi-auto dump systems. These systems help operators optimize load cycles and are especially beneficial for less experienced operators, helping to bridge skills gaps and enhance overall operational efficiency.

ABSOLUTE PEACE OF MIND

The WA700-8 is engineered for **easy maintenance and serviceability**. It features **maintenance-free batteries** for reduced downtime and a **centralized service center with sampling and quick fill ports** for easy and accurate fluid handling.

Komatsu provides comprehensive support for the WA700-8, including **Komtrax Step 5 and Komtrax Plus** for advanced asset management. Furthermore, the **Komatsu Care program and complimentary extended full warranty** offer customers complete peace of mind.

HARNESS THE POWER OF DATA FOR ULTIMATE TOTAL COST OF OWNERSHIP (TCO) PERFORMANCE

Integration with **Smart Quarry Site** provides site managers with production visualizations and real-time insights into machine movement, usage, and output. This overview enables improved quarry management and optimized fleet productivity and efficiency.

Additionally, the **pre-start inspection feature** facilitates proactive identification and reporting of potential equipment issues, while **real-time feedback displayed on the in-cab screen** further enhances operational efficiency and on-site safety.

This all-new wheel loader perfectly complements Komatsu's existing range of large wheel loaders, incorporating key

The Cat® 995's productivity and efficiency boosting technology.

attributes to boost customer value through performance, safety initiatives, operator comfort, efficiency, and digital technology.

Built to the same size as the Cat® 994K, the Cat 995 Wheel Loader offers a higher rated payload. This allows the 995 to load the 162-ton (147-tonne) Cat 785 truck in three passes, the 789 with its 213-ton (193-tonne) rated payload in four passes and the 265-ton (240-tonne) 793 in five passes. The one-pass reduction in loading compared to the 994K increases production and efficiency up to 33% when loading the 785, up to 25% loading the 789 and up to 20% with the 793.

The 995 has a number of standard and optional technologies available to help increase operator and loading efficiency. One simple technology feature helps the operator track the time it takes to get the bucket full. John Merek, large wheel loader market professional for Caterpillar, mentions that 10 seconds to fill a bucket is ideal but not to spend more than 15 seconds. “To let the operator know if these targets are being met, one centre display option is for dig time. It measures the length of the dig time, and it does it for each bucket fill,” he says.

Optional Autodig automates three of the dig cycle’s most difficult components in both rehandling and tough digging applications, improving productivity and reducing tire wear. One component, Tire Slip Prevention, automatically reduces rimpull before the tires are set and increases it when downward force is applied. Marek explains that this automates the left “impeller clutch” pedal, so the operator can focus their energy and attention elsewhere on their surroundings and technique.

“The left pedal,” he says, “controls rimpull, and there’s two main reasons to control the rimpull when the operator is digging. One is so the operator doesn’t spin the tire, and the second is so they don’t stall out the lift hydraulics.”

Pushing hard enough against the pile with any wheel loader causes that force to overcome the force of the lift arm trying to lift through the pile, which is called hydraulic stall. Caterpillar’s second component, Lift Stall Prevention, addresses this, and the combination of the Tire Slip Prevention and Lift Stall Prevention components fully automates left pedal operation during the dig.

Auto Set Tires automates one of the trickier components of the dig cycle. When the bucket contacts the pile, as soon as the bucket is far enough underneath the pile, the ideal technique is for the operator to apply an upward lift force to add more weight to the front tire, resulting in extra traction. “Auto Set Tires detects pile contact and automatically lifts against the pile to set the tires and increase available traction,” says Marek.

Optional operator Coaching provides training videos and monitoring of 21 different aspects of the way the operator is using the machine to help improve operator technique. Among the monitored operating technique aspects, the system looks at basic elements along with lesser-known best practices, including:

- how to properly reduce tire rotation,
- proper use of the kickouts,
- to avoid excessive usage of the impeller clutch,

- and how to time the bucket racking commands not too early and not too late.

“Take the perspective of a trainer,” offers Marek. “During the training, you can use the operator coaching tool’s videos on the correct and incorrect technique to improve the quality of your instruction. After the training, you can come back later to review the results report with each operator and use it to highlight where they are doing well versus things that still need to be improved.”

GEOGRAPHICAL DYNAMICS:

The mining wheel loader market is witnessing significant growth in regions rich in natural resources, including Asia-Pacific, North America, and Latin America. In 2022, the Asia-Pacific region commanded over 40% of the market share, primarily due to intensified mining activities in countries like China and India. Government initiatives aimed at strengthening the mining sector further bolster this growth. For example, the Indian government's ambitious target to elevate mineral production to $1 trillion by 2030 reflects a strong commitment to enhancing domestic mining capabilities, thereby driving the demand for advanced wheel loaders.

KEY MARKET TRENDS:

A significant trend shaping the mining wheel loader market is the increasing adoption of electric wheel loaders, driven by the need to reduce carbon emissions and improve energy efficiency. This shift aligns with a broader industry movement towards sustainable mining practices. As mining operators prioritize minimizing their environmental footprint, electric wheel loaders offer a viable solution that addresses both regulatory requirements and corporate sustainability objectives. The growing focus on electric wheel loaders is a pivotal aspect of the industry's ongoing transformation.

DIVERSE APPLICATIONS:

Mining wheel loaders find extensive applications across various industries, showcasing their versatility and effectiveness. Within the mining sector, their primary uses include material handling, ore loading, and site preparation. Beyond mining, these robust machines are also employed in construction, quarrying, and recycling, where their capacity to handle heavy loads efficiently is highly valued. The global construction machinery market is projected to reach $250 billion by 2026, further emphasizing the critical role of wheel loaders in facilitating essential operations across multiple sectors and ensuring a positive outlook for the mining wheel loader market in the years ahead.

Regional Contribution: North America held the largest market share at approximately 35%, followed by Asia Pacific (30%), Europe (20%), Latin America (10%), and the Middle East & Africa (5%). Asia Pacific was the fastest-growing region, propelled by increasing mining activities in China and India.

- **Market Performance by Type:** Large Wheel Loaders (Above 500 HP) dominated with 40% of the market share, followed by Medium Wheel Loaders (200-500 HP) at 35%, and Small Wheel Loaders (Under 200 HP) at 25%. Small Wheel Loaders were the fastest-growing sub-segment, driven by demand for compact and versatile equipment in smaller-scale mining operations.

- **Key Applications – Mining Types:** Open Pit Mining accounted for the largest share at 70%, while Underground Mining represented 30%. Underground Mining is the fastest-growing application, fuelled by advancements in deep mining technologies and increased resource extraction from underground deposits.

MINING WHEEL LOADER MARKET DYNAMICS:

The mining wheel loader market is undergoing significant transformations influenced by various factors that drive demand and shape the overall industry landscape.

These machines are central to mining operations, renowned for their efficiency in loading and transporting materials. The U.S. Geological Survey highlights the economic significance of the mining sector, contributing approximately 1.1% to the GDP. The global market for wheel loaders in mining is poised for substantial growth, driven by the increasing demand for minerals and the growing adoption of advanced machinery.

MARKET DRIVERS:

Several key factors are propelling the growth of the mining wheel loader market. The **expanding mining industry**, particularly in emerging economies, is a primary driver. The World Bank projects a 2.5% annual increase in global mining output, consequently boosting the need for efficient equipment. Furthermore, the increasing emphasis on **automation and technological advancements** in machinery is enhancing productivity and reducing operational costs. The integration of IoT technologies, for instance, enables real-time monitoring and improved maintenance schedules, leading to more efficient mining processes.

Another crucial driver is the growing focus on **sustainability and environmentally friendly practices.** Mining companies are increasingly investing in modern equipment that minimizes environmental impact while optimizing performance. This trend aligns with the industry's broader shift towards adopting greener technologies. The term "mining equipment market trends" encapsulates this evolving landscape of mining machinery and the demand for innovative solutions.

MARKET RESTRAINTS:

Despite the positive growth outlook, the mining wheel loader market faces several challenges. **High initial investment costs** associated with advanced wheel loaders can deter smaller mining operations from upgrading their equipment. According to Statista, the average cost of a new wheel loader can range from $100,000 to over $400,000, presenting a significant barrier for budget-conscious companies. Additionally, the **maintenance and operational costs** of these machines can be substantial, further complicating decision-making for many mining firms.

Furthermore, **regulatory challenges concerning environmental compliance** can also impede market growth. Mining operations are subject to stringent regulations, and non-compliance can result in penalties. Adapting to these regulations necessitates additional investments in equipment and processes, potentially discouraging some players from entering the market or expanding their operations.

MARKET OPPORTUNITIES:

Significant opportunities exist within the mining wheel loader market, particularly for manufacturers prioritizing innovation. The increasing trend towards **electric and hybrid wheel loaders** presents a unique opportunity to meet rising environmental standards and reduce fuel costs. A transition towards cleaner technologies is anticipated as operators seek sustainable alternatives to traditional diesel-powered machines.

Moreover, the **growing demand for minerals**, driven by sectors such as construction and renewable energy, creates a favourable market environment for wheel loader manufacturers. The International Energy Agency (IEA) projects that mineral demand for renewable energy technologies could double by 2040, providing a substantial boost to the mining sector and, consequently, the demand for mining equipment.

MARKET CHALLENGES:

The mining wheel loader market also faces notable challenges. One significant issue is the volatility of commodity prices, which can impact mining profitability and, subsequently, influence equipment purchasing decisions. Fluctuations in the prices of essential minerals like gold, copper, and coal can create uncertainty in investment strategies, affecting the demand for new machinery.

Additionally, the shortage of skilled labour in the mining sector poses a considerable challenge. As operations become increasingly automated, the need for skilled operators and maintenance personnel grows. This skills gap could hinder the adoption of advanced wheel loaders and other high-tech equipment. Companies must invest in training programs to ensure their workforce is proficient in handling new technologies, thereby adding to operational costs.

ADVANTAGES OF WHEEL LOADERS

1. **Superior Mobility:** Unlike their tracked counterparts, wheel loaders boast exceptional mobility, enabling swift travel across firm ground. This significantly cuts down on material transport times across a worksite.

2. **Enhanced Versatility:** The adaptability of wheel loaders through various interchangeable buckets and tools empowers operators to tackle a multitude of tasks. From digging and loading to lifting and carrying, these machines readily adjust to specific job demands.

3. **Quicker Operation:** The wheeled design facilitates faster travel speeds compared to tracked machines, leading to improved overall productivity, particularly across expansive sites.

4. **User-Friendly Operation:** Wheel loaders are generally straightforward to operate, especially for experienced personnel. Their intuitive controls, coupled with advanced technologies in modern models that aid in load management and safety, contribute to ease of use.

5. **Greater Cost-Effectiveness:** Often, wheel loaders present a more cost-effective solution than tracked loaders, especially for projects demanding high mobility or operation on solid surfaces. They typically require less maintenance and consume less fuel.

CONCLUSION

Wheel loaders are an indispensable asset across the construction, mining, and agricultural sectors. Their capacity to handle a diverse array of materials and tasks, combined with their high mobility and adaptable design, positions them as a preferred choice for operators globally. Whether the need is to move sand on a construction site, clear snow from a highway, or load materials in a mining operation, a wheel loader is well-equipped to handle the job. As technology continues its advancement, wheel loaders will undoubtedly remain a vital tool for boosting productivity and efficiency across various industries.

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