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Belarusian BelAZ to ship large batch of haul trucks to Russian coal miners

The Belarusian automobile engineering company BelAZ is getting ready to ship a large batch of vehicles to coal-mining enterprises in Russia. Eleven vehicles from this batch will be painted in colors of the flag of the Russian Federation, BelAZ representatives told BelTA.

As many as 16 BelAZ haul trucks with the carrying capacity of 130 tonnes and 220 tonnes will be shipped to coal-mining enterprises in the Republic of Khakassia, the Trans-Baikal Territory, and the Khabarovsk Territory. 130-tonne BelAZ 7513D haul trucks and 220-tonne BelAZ 7530G haul trucks enjoy well-deserved popularity in coal strip mines in Russia. These modern haul trucks are delivered as semi-knocked-down kits (SKD) to their destinations along the world's longest railway – the Trans-Siberian Railway, which unites Russia's central part with Siberia and the Far East.

Five haul trucks were already shipped to a Russian customer in March-April. Eleven more heavy trucks will be shipped in May-June. The driver's cabs and platforms of these vehicles have been painted with colours of the Russian flag to the customer's specifications.

BelAZ's 130-tonne and 220-tonne trucks handle most of the work involved in hauling mined rock as part of coal-mining operations in the Republic of Khakassia and in the Far East. These reliable and competitive vehicles with low operational costs and high performance provide a high level of workplace safety to coal miners in complicated conditions of coal strip mines.

Komatsu hits autonomous milestone

Komatsu has become the first company in the mining industry to autonomously operate a power agnostic electric drive haul truck while connected to a dynamic trolley line.

This represents a major step in Komatsu's ambition to combine electrification and autonomy to help mining customers reduce carbon emissions and enhance productivity.

By connecting haul trucks to an overhead power line during uphill travel, Komatsu's trolley assist system delivers electric power where it is needed most, improving energy efficiency and enabling trucks to travel faster in comparison to diesel models.

When integrated with the company's Frontrunner autonomous haulage system, the technology opens new doors for fuel savings and productivity gains.

"This milestone demonstrates the strength of our commitment to improving our integrated technology strategy, combining autonomous haulage with dynamic energy transfer and trolley capabilities," Komatsu director of global business development autonomous systems Martin Cavassa said.

"The ability to seamlessly transfer power to a moving truck operating without a driver is a pivotal achievement in our roadmap toward decarbonising mining operations and provides the pathway for managing battery operated trucks autonomously."

This achievement marks the first time in mining history that power has been transferred to a moving, driverless haul truck via a trolley line.

Komatsu first launched Frontrunner in 2008. The system now operates more than 875 autonomous haul trucks globally, having collectively moved over 10 billion metric tonnes of material.

A primary enabler of moving that amount of material is due to Komatsu's autonomous haulage solution working with ultra-class trucks, such as the 980E with a 363 metric tonne payload capacity.

Komatsu said the new breakthrough underscores its commitment to delivering integrated solutions that help customers meet their productivity targets, reduce total cost of ownership and support the responsible supply of essential minerals in a more efficient manner.

New Hope bolstered by upped coal sales

New Hope Group has recorded an increase in coal sales for the three-month period ending April 30, among other operational highlights.

The company sold 2.7 million tonnes (Mt) of coal for the period, a 3% increase from the prior period.

A total of 2Mt were sold from the Bengalla coal mine in New South Wales and 688,000 tonnes (t) were sold from the New Acland coal mine in Queensland, a 4% and 2% increase respectively.

"Bengalla mine is on track to achieve the midpoint of its 2025 financial year saleable coal production guidance range of between 10.1Mt and 10.9Mt, on a 100% basis," New Hope said.

New Hope saw a one% increase in saleable coal production, delivering 2.75Mt for the period. Bengalla produced 2Mt, a 3% increase, and New Acland produced 702,000t, a 4% decrease.

"Prime waste movement of 11.9Mbcm (bank cubic metres) was 11.4% higher than the previous quarter due to improved equipment availability, higher production rates and favourable mining conditions," New Hope said.

"Run-of-mine (ROM) coal production was 2.2Mt, down 15.8% as the mine cycled into the higher strip ratio portion of the resource. ROM inventory built during the prior quarter was unwound to maintain consistent feed to the Coal handling and preparation plant."

Prime waste movement at New Acland also saw a jump.

"Prime waste of 4.4Mbcm was moved from the Manning Vale East and Willeroo pits during the quarter, up 6.7% compared to the previous quarter, reflecting strong mining performance despite unfavourable weather," New Hope said.

"ROM coal production was 1.8Mt, a 12.9% increase on the previous quarter following steady exposure of coal blocks."

New Hope plans to increase coal production at New Acland to 5 million tonnes per annum by developing the Manning Vale West mining area.

"Mining across both Manning Vale East and Willeroo pits continues to be on schedule, with the final onboarding of employees completed during the quarter," New Hope said.

"New Acland Mine now has over 300 employees working at the operation. Further intakes are planned when mining commences in the Manning Vale West pit in the second half of 2026.

"The ramp up (of New Acland) will be in line with the onboarding of rolling stock and available rail paths, which are scheduled to increase over the next 12-18 months. Construction of access roads and other infrastructure will continue through 2025 and early 2026."

New Hope closed the three-month period ending April 30 with $155.2 million in underlying earnings before interest, taxes, depreciation, and amortisation.

Liebherr and ZF hit 10,000th loader milestone

Liebherr has hit a major milestone with the 10,000th XPower wheel loader rolling off its Bischofshofen production line.

The achievement marks a celebration of Liebherr's long-standing partnership with transmission specialist ZF Friedrichshafen AG.

The XPower travel drive combines hydrostatic and mechanical drives, offering both precision and power across different terrains and applications.

The hydrostatic drive delivers maximum efficiency for short loading cycles, while the mechanical drive provides the strength and fuel economy needed for long hauls and uphill work.

"This means that the XPower offers the highest efficiency in material pick-up and transport, as well as optimum acceleration and maximum performance in all loading cycles – even over long distances," Liebherr plant managing director of technology Herbert Pfab said.

The XPower boasts power-split ZF transmission, continuously and automatically adjusting the mixing ratio between the two drive paths, keeping the loader operating at peak performance no matter the job.

With more than 64 million operating hours already clocked by XPower models, the transmission's durability and reliability have been well proven in the field.

"The transmission from our partner ZF is a key component of the drivetrain in our XPower wheel loaders," Bischofshofen head of quality management Gerhard Pirnbacher said.

Liebherr's close collaboration with ZF has allowed for precise integration of the transmission into the entire drive system, significantly reducing fuel use compared to conventional loaders.

The machine is designed for longevity, low maintenance and heavy-duty mining environments.

The L 580 XPower anniversary model will be delivered to the BERGER Group in Passau and set to operate at a BERGER Rohstoffe GmbH quarry in the Bavarian Forest, featuring special decals and a hand-signed transmission by ZF employees, adding a personal touch to the landmark machine.

Alberta regulator approves Northback coal exploration project in Rockies

The Alberta Energy Regulator approved a controversial coal exploration project on the eastern slopes of the Rocky Mountains recently.

Northback Holdings Corp.'s project at Grassy Mountain was rejected in 2021, when a panel ruled likely environmental effects on fish and water quality outweighed potential economic benefits.

The project, located on an inactive legacy coal mine site in the Municipal District of Ranchland, was revived two years later. Last year, it was exempted from the Alberta government's decision to ban open-pit coal mines, because Northback's application was considered an "advanced" proposal.

A written decision from the regulator says it determined approving the project is in the public interest and the project won't have negative effects on water quality or wildlife, which many at public hearings argued will happen.

The decision grants Northback permits to drill and to divert water to the site, which was also a concern raised by farmers in drought-ridden parts of southern Alberta.

The approved deep drilling permit will allow Northback to drill more than 150 metres underground on both public and private land in its search for coal deposits.

The company will only be able to draw water from a nearby end pit lake that it owns and that's not directly connected to other water bodies or rivers, the decision says.

The decision notes that it's possible there will be some runoff from the lake, but it had been determined the project won't have any effect on water quality or quantity downstream.

It also says the potential for the project to generate toxic selenium is unlikely, "because there will be no excavation, no coal-mining operations and no new waste rock piles created."

"If the existing waste rock piles are not elevating downstream selenium levels, it is reasonable to conclude that these exploration activities are unlikely to elevate selenium levels," the decision says.

The regulator also determined that potential harm to wildlife is unlikely, as no new roads are to be constructed as part of the project.

The regulator was satisfied overall with the project's public interest, saying as it would provide employment opportunities to nearby residents, including First Nations communities, while allowing the company to continue investing in the area.

"We assessed the social and economic effects of the exploration program and found it to be positive," the decision says, adding that Northback plans to spend at least $2.5 million locally as part of the exploration.

"While the magnitude of the economic impacts may appear modest, they are proportional to the program scale and duration."

The decision says the company has spent over $1 billion since 2015 trying to advance the project but that it wasn't a consideration for the regulator.

The project will also give Albertans additional information on the scale of the coal deposit at Grassy Mountain, says the decision.

"The exploration program will contribute to the ongoing evaluation of this coal resource and, based on our assessment, will do so in an orderly, efficient and environmentally responsible manner," it says.

Rina Blacklaws, a spokesperson for Northback, said in an email the company thanked the regulator for the decision.

"With this outcome, Northback continues our commitment to bring benefits to Albertans while adhering to the highest environmental standards," Blacklaws said.

Opposition NDP environment critic Sarah Elmeligi said the decision is wrong.

"Albertans have been clear they do not want coal mining on the eastern slopes," she said.

"What a horrible day for Alberta."

Energy Minister Brian Jean said the government respects the regulator's "carefully considered decision on this application," noting it isn't an application to mine. He said Northback will be responsible for reclamation related to the exploration work.

"We reiterate our commitment to protect Alberta's waters and ensure that any development in the eastern slopes is done to the highest environmental standards," Jean said in a statement Thursday.

The decision followed days of public hearings in December and January, as well as a non-binding vote last year in the nearby community of Crowsnest Pass. About 72% of voters said they were in favour of the project.

The regulator notes that concerns were raised in the hearings that granting exploratory permits would lead to a full-blown coal mine. It says that possibility couldn't be factored into the decision-making process.

"Exploration is only one step taken by a resource company in the long and complex series of activities that may or may not lead to the development of a mine," the decision says. "Accepting the need for this exploration program does not constitute approval of a coal mine.

"If, in the future, Northback decides to proceed with mine applications at Grassy Mountain, it must follow a rigorous regulatory process that all resource development applications must follow."

Conditions attached to the exploratory permits require the company to dispose of drilling waste to the regulator's satisfaction, follow erosion control and weed management plans, and adhere to recommended environmental mitigation measures.

The company's permits are valid for five years, with the last three years to be set aside for reclamation work.

AustralianSuper rebuilds Whitehaven stake, signalling renewed appetite for coal

AustralianSuper has emerged as a substantial shareholder in Whitehaven Coal Ltd, having recently acquired more than 42.4 m shares to take a 5.07% stake in the ASX-listed miner, suggesting a potential shift back to metallurgical coal investments.

Whitehaven disclosed the holding in a Form 603 filed with the ASX recently, indicating the fund crossed the 5% threshold making it a substantial shareholder on May 13. The shares are held in custody by JPMorgan Nominees Australia.

Buying back in

The move comes roughly four years after AustralianSuper sold down its previous holding in Whitehaven. In 2021, the fund announced it had exited the coal miner, aligning the decision with a new commitment to achieve net-zero carbon emissions across its investment portfolio by 2050.

At the time, AustralianSuper said it would support the low-carbon transition through company engagement and initiatives such as Climate Action 100+. However, in announcing the divestment the fund did not change its climate policy to explicitly rule out future investments in metallurgical coal companies.

Transaction records from the latest filing show the fund has steadily rebuilt its position over the past four months, with notable buying activity in late March and April. On March 25 alone, the fund acquired more than 3.6 m shares at $5.48 per share.

Whitehaven last traded at $5.42, giving it a market capitalisation near $4.3 bn.

ESG pullback

The investment comes amid a global reassessment of environmental, social and governance (ESG) investing frameworks. Several major international banks have exited the UN-backed Net-Zero Banking Alliance in recent months, citing legal risks and political pressure, in a trend driven in part by the new US administration's criticisms of climate-related finance.

Scrutiny of ESG claims is also intensifying in Australia. This week, EnergyAustralia admitted that its 'Go Neutral' carbon offset campaign was likely misleading and said it would focus instead on direct emissions reductions after facing a landmark greenwashing suit.

Whitehaven, one of Australia's largest coal producers, has exposure to both thermal and metallurgical coal markets and is developing the Winchester South coking coal project in Queensland. Its shares are up around 12% over the past month.

Cat's new GET release slashes downtime

Caterpillar has launched its new single life cutting edges for medium wheel loaders, delivering longer life, lower operating costs and simplified maintenance.

This latest release expands Cat's range of ground engaging tools (GET), enhancing loader productivity by reducing both maintenance intervals and operating expenses.

The durable single-bevel design eliminates the need to flip edges, cutting downtime and offering up to 45% more value for customers who don't currently flip their cutting edges.

With up to 40% lower throwaway material costs compared to legacy Cat GET systems, depending on the loader model, the innovation supports lower total cost of ownership.

"Our new maintenance-free single life cutting edges design is a direct result of our voice-of-customer program and provides significant benefits for customers who prefer not to monitor wear and flip the edges," Caterpillar senior parts and service marketing manager Tilak Inturi said.

Built from through-hardened DH-2 steel, the thicker, high-performance edge boasts a longer life than standard cutting systems that are suitable for high-impact, high-abrasion environments.

The new cutting edge is also compatible with aftermarket buckets that share the same hole pattern, offering flexibility without the need for additional hardware.

Backed by Cat's warranty, the cutting-edge pieces fit the bucket with no end bits required.

Cat's single life cutting edges suit a wide range of loader models, including the Cat 950 series, XE, and GC models, making them a practical upgrade for demanding Australian conditions.

Northeastern Arizona depends on the jobs from coal plants. It's banking on Trump's push

Brantley Baird never misses a chance to talk history, from how his great-grandmother helped settle the town of Snowflake long before Arizona was granted statehood to tales of riding to school bareback and tethering his horse outside the one-room schoolhouse.

His family worked the land and raised livestock, watching the railroad come and go and cattle empires rise and fall. Then came the coal-fired power plants, built throughout northern Arizona and northwestern New Mexico to power progress in distant Western cities.

The plants would play their own role in the history of the region and could wind up at the center of its uncertain future.

The Cholla Power Plant stands just down the road from where Baird, 88, has been building a museum to showcase covered wagons, weathered farm implements and other remnants of frontier days. For years the plant powered the local economy, providing jobs and tax revenues for the unincorporated community of Joseph City, its schools and neighbouring towns, but now the vapours from its stacks have dissipated.

These days, change is in the air. Cholla is the latest in a long line of U.S. coal-fired plants to retire, shutting down in March. Arizona Public Service said it had become too costly to operate due to strict environmental regulations. The mandates were aimed at reining in coal-burning utilities, long viewed by scientists as major contributors to warming the planet.

Recently, however, President Donald Trump reversed course, signing new executive orders aimed at restoring " beautiful, clean coal " to the forefront of U.S. energy supplies. He urged his administration to find ways to reopen Cholla and delay the planned retirements of others. As part of his push toward energy independence, Trump has pledged to tap domestic sources – coal included – to fuel a new wave of domestic manufacturing and technology, namely innovations in artificial intelligence.

In the West, where the vision of far-off politicians sometimes crashes against

reality, Baird and many of his neighbours were encouraged that Trump put Cholla in the spotlight, but there's some scepticism about what the utilities will do with the plants.

"As many jobs as it gives people, as much help just to our school district right here that we get out of there, we're hoping that it will come back, too," said Baird, who used to work at the Cholla plant and has served on the Joseph City School Board.

Yet, he and others wonder if it's too late for coal.

Coal-burning plants retiring

Just weeks before Trump announced his plans, the U.S. Energy Information Administration projected a 65% increase in retirements of coal-fired generation in 2025 compared with last year.

The largest plant on that list is the 1,800-megawatt Intermountain Power Project in Utah. It's being replaced by a plant capable of burning natural gas and hydrogen.

Utilities, already looking to increase capacity, aren't sure Trump's orders will lead them back to coal.

"I think it's safe to say that those plants that are scheduled or slated to retire are probably still going to move in that direction, for a couple of reasons," said Todd Snitchler, CEO of the Electric Power Supply Association, which represents power plant owners. "One of which is it's very difficult to plan multimillion- or billion-dollar investments for environmental retrofits and other things on an executive order versus a legislative approach."

Last month, Republicans in the Arizona Legislature sent a letter to U.S. Interior Secretary Doug Burgum warning that the economic fallout from the 2019 closure of the Navajo Generating Station is still reverberating. The stacks were demolished, and the mine that supplied the plant closed.

At the San Juan Generating Station in northwestern New Mexico, operations ended in 2022.

Stuck in the middle are Joseph City and other communities where life revolves around a power plant. Residents hope Trump can help keep them in the energy race for another generation. From Joseph City to Springerville, they've been preparing to absorb major hits to the job market, tax rolls and school enrolment. Options are slim in Apache and Navajo counties – two of Arizona's poorest.

Utility executives told Arizona regulators recently that reopening Cholla would be costly for customers and that they plan to push ahead with renewable energy. The plant's infrastructure would be preserved as a possible site for future nuclear or gas-fired power generation, and the Springerville Generating Station could be repurposed once the last units are retired in 2032.

The utility that runs the coal-fired Coronado Generating Station, just 30 miles (48 kilometre's) away in St. Johns, also has plans to convert to natural gas.

Wind resistance

In Springerville, the idea of spoiling the surrounding grasslands and ancient volcanic fields with 112 wind turbines – with blades standing taller than Seattle's Space Needle – provokes outrage. Banners and posters objecting to the proposal are plastered around town.

"They all know that this won't work, that we can't rely on wind and solar," said Doug Henderson, a Springerville plant retiree who now sits on the town council. He says coal-fired generation can accommodate swings in demand, regardless of whether there's sunshine or wind.

Springerville Mayor Shelly Reidhead and others are fighting to keep the wind farm from happening, saying repurposing the Springerville coal plant would mean more jobs and preserve the surrounding landscape.

"We also survive on tourism and people don't want to come here and look at that," Reidhead said of the turbines.

The Western Drug and General Store is adorned with tiny American flags tacked up outside. A sign advertises canning supplies, but locals joke that you can get anything here – from slippers to rifles.

Andrea Hobson works the register and knows everyone by name. She moved to Springerville about 20 years ago from California and says it's hard to imagine the community without the power plant.

"It would be a ghost town. It really would," she said. "That's the heart of this town."

Filling the economic void

Springerville's leaders have lost sleep trying to figure out what industries might fill the void. At stake are about 350 jobs, dozens of contract employees and the businesses they support – from the general store and the new frozen yogurt shop to the hospital and local churches.

Some workers drive an hour to the Springerville plant every day, meaning other communities also will lose out, said Randel Penrod, a former crew manager at the plant. With retirement looming, the plant has trimmed its workforce.

Henderson, the Springerville town council member, fears it could take years to permit a new plant.

Reidhead is more hopeful after attending meetings with members of Arizona's congressional delegation and utility executives. She thinks the Trump administration can reduce the "red tape" and get new plants up and running. The development of artificial intelligence and its thirst for power gives the mission a sense of urgency.

"I think our politicians at a state level have realized with AI's need for the power, that if we don't get on board and get on board soon we're going to be left behind," she said.

Some energy analysts say Trump's support of coal is mostly symbolic, since utilities hold the keys. Others say diversifying energy sources is a must as the U.S. sees increases in power demand predicted for the first time in decades.

"AI may be artificial, but the electricity it needs is very real – and in some regions, coal still keeps the lights on when other sources may blink," said Scott Segal, a partner with the Washington D.C.-based firm Bracewell LLP.

He said power markets don't care about politics – just reliability, affordability and sustainability.

Just outside of Joseph City, crews are building what will be one of the largest solar and battery storage projects in Arizona. The solar panels will be installed on leased private land, including Baird's sprawling ranch.

While not a fan of all the dust being kicked up, Baird knows the advent of solar is just another of many changes he has seen in his lifetime – and he has no idea what the next 100 years might look like.

"Hell, who knows?" he said. "You know, when it comes right down to it, we'll just wait and see."

How thickener technologies can optimise tailings

Balancing environmental responsibility with operational efficiency is a growing concern for mining operations worldwide, with tailings management a key aspect.

Tailings management is a growing concern for mining operations around the world, balancing environmental responsibility with operational efficiency.

As a leader in mineral processing, McLanahan provides insight into how different thickener technologies can optimise tailings management, improve water recovery, and enhance site sustainability.

Thickeners are essential for liquid–solid separation in mining operations, reducing the volume of slurry material sent to the settling pond or tailings storage facilities (TSFs) while recovering valuable process water.

The right thickener can help mines reduce pond size or eliminate the need for ponds or TSFs altogether, thereby reducing their environmental footprint, streamlining operations, and lowering permitting challenges.

Understanding thickener types

Most thickener types operate by using a chemical polymer, such as a flocculant, to agglomerate solid particles in the slurry, allowing them to settle and discharge while the clear liquid overflows and is collected in a storage tank.

There are variations in thickener design and performance to achieve different process goals. McLanahan outlines the primary thickener types and their applications.

High-rate thickeners

High-rate thickeners are commonly used in mining operations to achieve moderate underflow density and high liquid recovery with relatively low chemical usage.

These units feature a sloped floor and a rotating rake mechanism to assist with compacting the mud bed.

They are a cost-effective choice for operations looking to improve tailings management while maintaining reasonable capital and operational expenditures.

Ultra rakeless thickeners

Ultra rakeless thickeners eliminate moving parts, relying instead on a deep tank and steeply sloped floor for solids settling.

While this reduces maintenance, it increases reliance on chemical additives and requires longer residence times – the duration solids remain in the thickener before discharge. This allows for better settling and compaction but can slow production rates.

Ultra rakeless thickeners are an attractive option for operations looking to minimise mechanical complexity, but it's important to factor in throughput requirements and the cost of chemicals when assessing long-term viability.

High-density thickeners

High-density thickeners offer improved underflow density and water recovery compared to high-rate thickeners.

Their design features include taller tanks, steeper floor slopes and, in some cases, vertical pickets on the rake mechanism to enhance compaction.

These thickeners are ideal for operations wanting to reduce tailings storage requirements while maximising process water recovery.

Paste thickeners

Paste thickeners provide the highest possible solids concentration using gravity alone, often producing an underflow with a paste-like consistency.

Their tall tank design, steep floor slope, and extended bed residence times allow for maximum liquid recovery, making

them well-suited to water-constrained sites.

Paste thickeners can significantly reduce water loss in tailings disposal, particularly in areas where water is scarce. This makes them a strategic investment for long-term sustainability.

Other thickener variants

In addition to primary options, various other thickener designs exist, each with unique operational benefits:

- Bridge thickeners – feature a mechanism suspended off a bridge spanning the tank's diameter
- Clarifiers – prioritise overflow clarity rather than underflow density
- Column thickeners – incorporate a centre pier to support the bridge structure.
- Conventional thickeners – large-diameter, low-aspect-ratio tanks that often operate without chemical flocculants
- Elevated thickeners – raised tanks that offer improved access to underflow pumps
- On-ground thickeners – built directly on the ground, reducing construction costs

These designs can sometimes be combined. For example, a high-rate thickener can also function as a bridge thickener or an elevated thickener, depending on site-specific requirements.

Selecting the right thickener

Determining the most suitable thickener for a given application requires consideration of factors such as material characteristics, process parameters, and operational goals.

Conducting material testing can help operators identify the optimal type and size of thickener needed. Tailings management is not a one-size-fits-all approach.

By understanding the strengths and limitations of different thickener designs, operations can make informed decisions that enhance efficiency, reduce costs and promote environmental sustainability.

The future of tailings management

With increasing pressure on the mining industry to reduce its environmental impact, the role of thickeners in tailings management is becoming even more critical.

As technology advances, new thickener solutions are helping operations recover more water, minimise waste and improve overall efficiency.

Investing in the right thickener not only improves water recovery and reduces reliance on TSFs but also contributes to a more responsible and efficient mining operation.

By leveraging the right thickener technology, mining operations can enhance their sustainability efforts while ensuring long-term operational efficiency.

McLanahan's solutions offer proven reliability backed by decades of innovation and industry leadership.

Production Goes Up in DPRK

The production of coal has increased by more than 107 percent throughout the Ministry of Coal Industry, compared with the same period of last year thanks to the indefatigable fighting spirit and creation of the officials and workers in the field of coal industry.

Officials of the Ministry of Coal Industry and relevant units are giving priority to prospecting and tunnelling while securing reserve cutting faces and conducting operations and commands with the main emphasis on strengthening the material and technical foundations of coal mines.

Officials and coal miners of the Pukchang Area Youth Coal-mining Complex are carrying out their production plans set at higher level.

The coal miners of the February 8 Jikdong Youth Coal Mine of the Sunchon Area Youth Coal-mining Complex secured more than 80 reserve cutting faces this year.

The Tukjang Youth Coal Mine under the Tukjang Area Coal-mining Complex is boosting the production every day.

The coal miners in the northern part of the country are also making collective innovations by displaying their strong practical ability.

The Onsong Area Coal-mining Complex conducts the frontline-style political work to arouse coal miners to the socialist patriotic coal production movement so that all the pit faces are seething with the drive for increased production to implement the decisions of the Central Committee of the Workers' Party of Korea.

The Soksong and Myongchon coal mines of the Myongchon Area Coal-mining Complex are giving priority to the main tunnelling and the preparatory tunnelling while ensuring the rapid transport of coal to provide a guarantee for increased production.

What next for energy? king coal, queen gas, or a renewables transition

"Natural gas is queen," gushed Exelon energy executive John Rowe at the American Enterprise Institute in Washington. It was 2011, shortly after the Fukishima disaster boosted concerns about nuclear energy, and anxiety over global warming spawned scrutiny of king coal. Natural gas, which has lower emissions than coal when burned, was seen as the answer to a safe, cheap, and clean energy future. Largely due to a new way of extracting gas called fracking, the US grew from being a minor global player in 2014 to become the world's largest gas producer by 2023.

Freedom Gas

As the US aimed to increase its fossil fuel exports, natural gas was rebranded from "queen" to promoting "freedom." Referencing the 75th anniversary of the US helping to liberate Europe from Nazi occupation, US Energy Secretary Rick Perry raved: "the United States is again delivering a form of freedom to the European continent … And rather than in the form of young American soldiers, it's in the form of liquefied natural gas." US Undersecretary of Energy Mark Menezes effused, "Increasing export capacity from the Freeport LNG project is critical to spreading freedom gas throughout the world by giving America's allies a diverse and affordable source of clean energy." (In a spoof on the rebranding of natural gas, Slate News joked: "Spreading freedom gas sounds like what happens when you're newly single and suddenly have the apartment to yourself.")

So, if it produces less pollution when burned, promotes freedom in Europe, and even guarantees US energy independence, what's the problem with natural gas? Turns out a lot according to Cornell professor Robert Howarth, who, in addition to being my colleague, proudly bears his title as the "Climate Scientist Fossil-Fuel Companies Can't Stand."

Fracking

Let's start with the basics. Natural gas is almost completely composed of methane. Although we hear a lot about CO2 and global warming, methane is actually 80 times stronger as a greenhouse gas than CO2 over the first 20 years after it's emitted. In other words, methane warms the atmosphere a lot faster than CO2 in the near-term. Although methane's potency goes down over time, scientists agree that we need to draw down emissions immediately – which means the next twenty years are critical.

Natural gas can be extracted by conventional wells or by fracking – either way its emissions when burned are lower than those of coal. But natural gas produced via fracking goes through a series of stages from buried in the ground to burned at the power plant. And, at each stage, methane can leak into the atmosphere as "fugitive emissions." For example, methane escapes when rocks are injected with high-volume water to open up passages for methane extraction and escapes into the atmosphere through equipment leaks, including pressure relief valves that vent gas as a safety precaution. In both conventional and fracked natural gas, additional fugitive emissions occur during transport, storage, and distribution.

Fugitive Methane Emissions

Back in 2011, when Howarth first tried to estimate the total amount of methane emissions from ground to power plant, there wasn't a lot of data to draw on. Using the best figures available, Howarth and colleagues estimated that during the life cycle of a typical fracked gas well, 3.6 to 7.9% of the total production escapes to the atmosphere as methane. Recognizing the influence of Howarth and fellow Cornell scientist Tony Ingraffea on fracking policy, Time Magazine named them, along with actor and anti-fracking activist Mark Ruffalo, people who mattered. (Others on the 2011 list included Jeff Bezos, Hillary Clinton, Barack Obama, Vladimir Putin, and Kim Jong Il.)

Liquified Natural Gas (LNG)

Fast forward to 2024, and Howarth came out with another controversial paper–this time questioning the wisdom of expanding LNG export facilities in Louisiana and Texas. As with his earlier work on fracking, Howarth

A general view of the steelworks and coal loading facility in Wollongong, Australia

painstakingly calculated fugitive emissions throughout the life cycle of LNG from extraction to burning in Europe or China. Emissions come from the energy required to convert natural gas into LNG, as well as from burning fuel and evaporation of LNG during transport. Given the magnitude of these and other LNG emissions, Howarth concluded: "With an even greater greenhouse gas footprint than natural gas, ending the use of LNG should be a global priority. I see no need for LNG as an interim energy source, and note that switching from coal to LNG requires massive infrastructure expenditures, for ships and liquefaction plants and the pipelines that supply them. A far better approach is to use financial resources to build a fossil-fuel-free future as rapidly as possible."

Controversy over Gas Emissions

Not surprisingly, the oil industry and some scientists were not happy with Howarth's findings and the vitriol began to flow, questioning his credibility and motives.

Critiques of Howarth's research on natural gas (followed by my responses):

- Howarth used a significantly higher leak rate than U.S. Environmental Protection Agency estimates. (Howarth has since revised his estimates based on a 2024 paper published in the prestigious journal Nature, which integrated nearly one million observations of emissions from satellites and airplane flyovers. Using the Naturepaper's lower leakage rate of 2.8%, Howarth calculates that leakage accounts for 38% of total LNG emissions.[1]Further, emissions can vary widely – fracking in Pennsylvania's Marcellus shale produces significantly lower emissions than fracking in Texas and New Mexico's Permian basin, a result of limited infrastructure, regulatory leniency, and low gas prices. What's more, fewer than 2% of well sites contribute 50-79% of emissions, suggesting the need for interventions to limit emissions at the worst sites. As University of Texas petroleum and geosystems engineer Arvind Ravikumar wrote in an email: "The key issue is that assumptions really make-or-break your analysis and overly broad assumptions about supply chains can result in misleading emission intensities.")
- The leakage rate will decline as leaks are identified and fixed. (Hopefully, Howarth's work has led to industry efforts to reduce fugitive emissions. But this critique is like saying we don't need to look at coal's emissions now because coal plants will put on scrubbers in the future.)
- A time frame limited to 20 years, exaggerating methane's impact which trails off over longer periods. (The time frame used in emissions studies impacts the results, but a short time frame is critical given the mandate to reduce greenhouse gases as soon as humanly possible. Ignoring methane today will lead to further irreparable harms to the environment and human wellbeing.)
- Howarth received funding from the Parks Foundation, which opposes fracking. (This critique feels a little rich given that the oil and gas industry also funds emissions research.)
- A fifth concern is that Howarth made his LNG analysis public before it went through peer review. Aware of the risk to his reputation, yet urged on by fellow scientist/activists, Howarth made the decision to self-publish his findings because he was convinced that the Biden administration needed to understand the climate consequences of expanding LNG infrastructure. In fact, Biden did use Howarth's report in deciding to pause LNG export facility expansion. Howarth's paper has since gone through extensive peer review and been published in a reputable journal, giving scientific credibility to

NOCHTEN, GERMANY – APRIL 30: In this aerial view the Boxberg coal-fired power plant stands behind

his concerns about LNG as a transition fuel to renewables. Howarth, in the meantime, takes pride in his controversial role as a scientist/activist. As he shared with the Wall Street Journal, "Albert Einstein spoke extensively about the moral obligation of scientists to push their information into policy. It's part of who I am."

- Future LNG Demand and Tariff Wars
  A battle rages not only over the scale of methane emissions from natural gas, but also over the economic outlook for LNG. According to Shell Oil, "Global demand for LNG is forecast to rise by around 60% by 2040." The Institute for Energy Economics and Financial Analysis (IIEFA) has a totally different take: "Lackluster demand growth combined with a massive wave of new export capacity is poised to send global liquefied natural gas (LNG) markets into oversupply within two years." IIEFA cites the 20% decline in Europe's gas consumption over the past two years, and smaller declines in Japan and Korea driven by the transition to nuclear and renewables.

Not surprisingly, the Trump administration sees LNG as a card to play in its tariff wars, hoping LNG exports will eliminate trade deficits with Europe. But, according to the Columbia University Center on Global Energy Policy, "Whatever Trump may think he is gaining in the short-term by pushing more US LNG exports to EU countries, it will hardly be a sustainable solution to bridging the US-EU trade." Unfortunately for trade deficits, European utilities (not politicians) actually purchase gas. They are wary of entering into long-term contracts with US LNG suppliers as LNG demand declines, and of being exposed to international methane reduction agreements that the Trump administration is likely to ignore. The LNG trade issue is complicated by gas prices, which Trump has promised to lower, thus counteracting his goal of reducing the trade deficit.

Energy Emissions: More than Just Burning

As scientists and oil executives continue to clash over the methane emissions of LNG–and over future demand for LNG–the point remains that we need to go beyond the emissions from simply burning gas or coal to understand their climate footprint. We need to take into account the fugitive emissions of their entire life cycle, from extraction to transport to burning, and even closing down wells and mines. And we need to compare the costs of building new LNG infrastructure to hastening the transition to renewables.

[1] The authors of the Nature study also point out the annual financial costs of fugitive emissions: roughly $1 billion in lost commercial gas and $9.3 billion in social costs, such as declining coastal property values due to fire or sea level rise.

Marianne Krasny, *Marianne Krasny is a professor at Cornell University*

India cuts imports by over 9% in FY25

India's coal import in the April-February period of 2024-25 dropped 9.2% to 220.3 million tonnes (MT), resulting in foreign exchange savings of about Rs 53,137.82 crore, according to an official statement.

The country had imported 242.6 MT coal in the year-ago period.

The non-regulated sector, excluding the power sector, experienced a more significant decline, with imports dropping 15.3% year-on-year.

"Although coal-based power generation grew by 2.87% from April 2024 to February 2025 compared to the previous year, imports for blending by thermal power plants sharply decreased by 38.8%," the coal ministry said in a statement.

This highlights the country's ongoing efforts to reduce its dependence on imported coal and enhance self-sufficiency in coal production.

The Centre has implemented several initiatives, including commercial coal mining, to enhance domestic coal production and reduce imports.

These efforts have also led to a 5.45% growth in coal output during the April-February period of 2024-25 compared to the same period of 2023-24.

In northern China, a glimpse of the future in smart coal mining

At the Malan Mine in Taiyuan, north China's Shanxi province, a group of new "workers" has just reported for duty. But instead of helmets and headlamps, these workers come equipped with sensors, software and precision memory-cutting technology.

Managed by XiShan Coal Electricity Group Co., Ltd. (XiShan Group), a subsidiary of Shanxi Coking Coal Group Co., Ltd., the mine now runs with the help of an intelligent control center above ground. Here, Ding Chao, deputy technical leader of the mining preparation team, sat in front of a smart mining console. With a tap of a button, he set an automated shearer in motion more than 100 meters below. Its rotating drums sliced cleanly into the coal seam, sending streams of freshly hewn coal – known locally as "black gold" – onto a conveyor belt bound for the surface.

Live footage from underground work zones flickers across monitoring systems. Hao Yirui, head of the coal mining section, watched closely. "If the belt drifts even slightly off track, we can notify workers immediately," he explained.

The scene is emblematic of a broader transformation underway in Shanxi, China's largest coal-producing region. As smart mining continues to expand, technologies like intelligent mining systems and robotic inspectors are becoming indispensable partners underground, working in coordination with human operators.

How does technology coordinate with human labour?

Central to this shift is the smart mining system – a digital "brain" that integrates control, coordination, and diagnostics across the mine. Once-manual tasks have been translated into automated commands. Workers now guide machines remotely, relying on pre-programmed "memory-cutting" paths that reduce manual labor and boost mining efficiency.

Smart technology also plays the role of "safety supervisor."

At the nearby Tunlan Mine, also managed by XiShan Group, an AI-powered early warning system adds a layer of vigilance. At 2:55 a.m., one recent night, Wang Jianping, a member of the electromechanical maintenance team, received an alert on his phone: a fan in the equipment room had malfunctioned. Technicians were dispatched immediately, the fault repaired within minutes.

The platform monitors not only machines but also human activity, issuing alerts to workers when potential hazards are detected. It is, in effect, an always-on safety supervisor.

Roof collapses – among the most feared threats in coal mining – remain a critical concern. Traditionally, installing hydraulic shields to hold up the roof above the work face was a labour-intensive and risky task – often requiring two workers and leaving them exposed to falling rocks. Now, equipped with infrared sensors, the shields advance automatically, extending their hydraulic arms to stabilize the coal wall without putting workers at risk.

"In the past, we needed over a dozen workers at a single face and still couldn't keep up," said Hao. "Now we run day shifts only, with a team of only eight. Output hasn't dropped – in fact, we've improved productivity by over 40 percent."

After extraction, how is the coal safely delivered to the processing plant?

Even after the coal is brought to the surface, the technology continues to work. At the Malan Mine, raw coal travels down a steep 1,142-meter incline toward the processing plant. Along the way, a smart inspection robot glides along the belt, scanning for signs of trouble.

Its data-gathering cameras can track belt alignment and coal spillage. The built-in pickup microphones record and analyze mechanical sounds to detect anomalies and trigger automatic alarms if anything seems off. An infrared thermal imaging camera "feels" for abnormal heat in hard-to-reach areas, alerting workers to potential issues before they escalate.

"It's like giving the robot human senses," said Guo Tianjun, chief engineer of the Malan Mine's electromechanical department. "It sees, hears, and feels, eliminating inspection blind spots and easing the burden on workers. It's reliable."

To date, the Malan and Tunlan Mines have jointly built 16 smart mining work faces. Across Shanxi, more than 50 percent of coal production capacity comes from mines powered by intelligent systems.

"With continued upgrades in rock-coal recognition and underground positioning technologies, fully unmanned mining is no longer a distant vision – it's just around the corner," said Hao.

Photo shows an intelligent work face of the Tashan Mine in north China's Shanxi province. (Photo provided by Jinneng Holding Group)

China launches world's first fleet of driverless mining trucks

China recently deployed the world's largest fleet of driverless electric mining trucks without driver's cabins in Inner Mongolia. The fleet consists of 100 vehicles equipped with autonomous driving technology.

These vehicles are equipped with a 564 564-kilowatt-hour lithium iron phosphate battery pack. When fully charged, they can carry 90 metric tons of goods and travel about 60 kilometres.

Unmanned mining trucks loaded with stripped soil and rock make their way to the dumping site at the Yimin coal mine, Hulun Buir, north China's Inner Mongolia autonomous region,

The economics of metallurgical coal

The global metallurgical coal market is projected to reach $17.5 billion by 2030. The industry is expected to create hundreds of thousands of direct jobs globally by 2025, with significant growth in India and Southeast Asia. Steel production, which is reliant on metallurgical coal, is projected to grow steadily through 2030, driven partly by renewable energy infrastructure needs. Experts project that the demand for metallurgical coal will be consistent demand through 2026.

One such expert is Nicholas Green, who will serve as the head of business development and engineering at Oak Grove Mining in Alabama. He stated that "[t]he world needs to understand that metallurgical coal is fundamentally different from thermal coal – it's a critical component of the green energy transition… without it, we simply cannot build the wind turbines and solar infrastructure needed for our renewable future."

In the hills of Alabama, a revolution in coal mining is taking shape. As global economies struggle to balance industrial growth and environmental responsibility, metallurgical coal – a crucial component in steel production – has emerged as an unlikely bridge between these competing demands.

"Oak Grove is creating thousands of jobs while providing a critical resource for the energy transition," Green explains. The mine will rely on his experience developing mining operations across several countries to lead Oka Grove in developing new methods of mining operations that target metallurgical coal for steel production rather than thermal coal for power generation.

However, operations at Oak Grove and other similarly positioned mines in the U.S. must also focus on environmental responsibility. Moreover, the industry's impact on employment presents compelling numbers. In 2023, mining operations in the United States directly employed over 45,000 workers. The mining industry employs personnel in the following roles: mining engineers, geologists, heavy equipment operators, mine safety specialists, blasting technicians, environmental engineers, metallurgists, and quality control specialists, as well as various support services positions, like administrative or HR staff.

Throughout his career, Green's business approach to mining has proven successful in creating thousands of jobs across the globe. His strategy reflects a larger shift in the industry toward environmental consciousness. Specifically, under his leadership mines have implemented advanced water management systems and reclamation practices that go beyond regulatory requirements, with operations incorporating real-time environmental monitoring and automated systems that minimize both environmental impact and worker exposure to hazardous conditions.

Further, as developing nations continue their industrial expansion, the World Steel Association projects global steel demand to increase steadily through 2030, creating sustained demand for metallurgical coal. This growth presents both opportunities and challenges for mining operations in the United States. As a result, operations such as Oak Grove are not just mining coal; they are providing a critical resource for global development while creating sustainable, well-paying jobs in communities that need them. As the world transitions toward renewable energy, the mining industry finds itself in the complicated position of being both part of the old and new energy economy. The challenge ahead lies in balancing these competing demands while maintaining environmental and social responsibilities.

Things to know about the US coal industry and proposed changes under the Trump administration

President Donald Trump's administration has proposed several changes that would affect the struggling U.S. coal industry.

Trump issued executive orders this month to allow mining on federal land. He has used his emergency authority to allow some older coal-fired power plants set for retirement to keep producing electricity to meet the rising demand amid the growth in data centers, artificial intelligence and electric cars.

The Republican president also granted nearly 70 older coal-fired power plants a two-year exemption from federal requirements to reduce emissions of toxic chemicals.

Trump's government efficiency team, run by Elon Musk, made plans earlier this year to terminate the leases of 34 U.S. Mine Safety and Health Administration offices in 19 states.

The coal industry once provided more than half of U.S. electricity production. But it has been in steep decline for decades as operators went out of business and utilities installed more renewable energy and converted coal-fired plants to be fuelled by cheaper and cleaner-burning natural gas.

U.S. coal production was at 1 billion tons (907 million metric tons) in 2014 and fell to 578 million tons (524 million metric tons) by 2023, the latest year available, according to the U.S. Energy Information Administration.

Coal employment nationally peaked in the 1920s when there were about 900,000 miners. It was at about 350,000 in 1950 and has declined steadily since 1980. After the coronavirus pandemic, employment rebounded from 2022 to 2023, rising 4.2% to 45,476. West Virginia employed the most miners at 14,000, followed by Kentucky at 5,000. About half of the nation´s 560 coal mines are located in West Virginia (165) and Kentucky (112). Despite having just 15 mines, Wyoming was the highest-producing coal state due to mechanization and more accessible coal.

Mining fatalities over the past four decades have dropped significantly. There have been 11 or fewer deaths in each of the past five years, according to MSHA.

MSHA is responsible for enforcing U.S. mine safety laws. It is required to inspect each underground mine quarterly and each surface mine twice a year. The cuts proposed by Musk's so-called Department of Government Efficiency would require MSHA inspectors to travel farther to get to a mine, and that could mean less thorough inspections, said Jack Spadaro, a longtime mine safety investigator and environmental specialist who worked for that agency.

According to the DOGE website, ending the MSHA leases is projected to save $18 million. It is unclear whether inspectors´ positions and other jobs from those offices would be moved to other facilities.

Seven of the MSHA offices set for closing are in Kentucky and four are in Pennsylvania. West Virginia is among the states with two targeted offices. Also under consideration for closure are the Office of Surface Mining Reclamation and Enforcement facilities in Lexington, Kentucky, and Tulsa, Oklahoma, shrinking the national footprint of an agency created during the Carter administration to restore land damaged by strip mining, and reclaim abandoned and damaged mine lands.

A recent review of publicly available data by the Appalachian Citizens´ Law Center indicates that nearly 17,000 health and safety inspections were conducted from the beginning of 2024 through February 2025 by MSHA staff in the facilities on the chopping block.

Industry advocates have long contended that there are other uses for coal, some of which use cleaner technology.

Canonsburg, Pennsylvania-based Core Natural Resources is working to develop a process using West Virginia coal to create a synthetic material that can be used as an anode for lithium-ion batteries, reducing U.S. dependence on countries such as China, according to Matthew Mackowiak, the company´s director of government affairs.

Core recently acquired a company that turns coal into carbon foam that produces composite tooling used to make nose cones and plane wings for the U.S. defense industry.

"Whether or not there is any more coal-fired generation in the future, obviously that´s something else to talk about in the future," Mackowiak said. "But at the very least, we need to be focused on maintaining our current coal fleet."

This story was first published on April 27, 2025. It was updated on April 28, 2025, to correct the metric conversion for 1 billion U.S. tons of coal. The conversion is 907 million metric tons, not 907,000.

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 – utilizing 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 revolutionized 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, specialized 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 maximize 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.

- Minimized 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.

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 optimize 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 revolutionized 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.

Transnet revolutionises belt cleaning at its flagship bulk handling terminal

Transnet's Richards Bay bulk minerals terminal handles an extensive array of materials for import and export.

The largest port operator in South Africa, Transnet, has made a fresh investment to boost productivity at its flagship bulk handling terminal by switching to innovative CleanScrape® belt cleaners from Martin Engineering. Transnet's Richards Bay bulk minerals import-export line in KwaZulu-Natal on South Africa's southeast coast handles 20 million tonnes of commodities every year – exporting magnetite, ferrochrome, bauxite and woodchips to destinations worldwide, and importing materials such as sulphur, coking coal and alumina.

With a network of around 30 conveyors moving materials in and out of the port, 24 hours a day, 7 days a week, an efficient operation is essential. Transfer times must be kept to a minimum so shipping remains on schedule – that means maximising speed and volume without running the risk of excess spillages, blockages and buildups which, if left unchecked, can lead to conveyor damage or total breakdown. The plant also has some of the highest conveyor discharge points for loading the cargo holds of massive dry bulk carriers, making maintenance access challenging if things do go wrong.

When the stakes are this high, only CleanScrape® conveyor belt cleaners were capable of achieving the desired result, according to Transnet. Featuring unique patented technology, the system uses a matrix of tungsten carbide wear tips lightly tensioned across the discharge pulley in a three-dimensional helix shape.

Despite the low contact pressure between the cleaner and the belt, this arrangement is proven to remove as much as 95% of potential carryback material, not only delivering superior cleaning performance, but also lasting up to four times the service life of conventional blades – and in many cases much longer. Only occasional tension adjustment is needed after installation of CleanScrape®, with minimal ongoing maintenance and a significant whole-life cost reduction.

Back in 2015, Transnet led the way as the first operator in South Africa to trial CleanScrape®, keen to see if it could improve performance on the plant's most challenging conveyor belts at Richards Bay. Conveyors of 1350mm and 1500mm (54 in. and 60 in.) width were experiencing excessive spillage in the discharge zones with fines adhering to belts and causing carryback to spill along the belt path and accumulate underneath the framework and out into walkways.

Following installation of CleanScrape® by Martin's experienced technicians, it wasn't long before the innovative design began proving its worth. Further installations followed on eight more conveyors, especially those at transfer points where access is difficult and space is limited, with no room for a conventional belt scraper and mainframe.

Transnet's Technical Supervisor, Cyril Dludla said: "There has been a huge improvement in terms of spillage since the new scrapers were installed, and as a result we will be installing more CleanScrape® belt scrapers to improve on spillage across the entire plant in Richards Bay. We

are grateful to the team from Martin Engineering who installed the system at the site and continue to monitor performance."

Now, as part of a major plant overhaul, Transnet has followed through on its commitment with the installation of CleanScrape® cleaners on a further 12 belts, meaning that all the plant's key conveyors are fitted exclusively with CleanScrape® primary cleaners.

Complementing the primary cleaners are Martin's SQC2 (SC16 in Africa) secondary belt cleaners, which feature a unique installation and removal guide/cradle for safe and easy servicing. The SQC2's are fitted with blades that can withstand the most abrasive bulk cargoes and, combined with CleanScrape® primaries, keep the belts running with virtually no spillage.

Janco Shulze, Martin Engineering's Sales Representative in KwaZulu-Natal said: "We're grateful to the team at Transnet who put their faith in Martin Engineering and we are delighted to be working with them to achieve a clean and efficient operation. Thanks to the reliability and performance of CleanScrape®, Transnet's maintenance teams can be deployed to other critical areas in the plant, ensuring hassle-free continuous running of essential belts."

Lindokuhle Qwabe, Technical Manager (Export) said the earlier CleanScrape® installations not only outperformed conventional cleaners but also surpassed everyone's expectations: "Some of the CleanScrape® belt cleaners have been in place for over four years – they are adjusted or re-tensioned now and again, significantly reduced wear part costs and allowing us to keep production moving smoothly without frequent maintenance interruptions."

Janco Shulze added: "We're confident that the latest CleanScrape® installations will be a game-changer for Transnet's total productivity, and the arrangement we have in place allows our service team to operate a robust inspection and maintenance regime – not that our belt cleaners need much attention! Martin Engineering is all about solving problems and, thanks to CleanScrape®, we're preventing problems from arising in the first place."

Designed with safety and efficiency in mind, Martin Engineering equipment is engineered to offer agnostic, retrofitted and customized solutions to accommodate any belt speed and material characteristics. The company installs and services conveyor equipment at numerous ports around the world and understands the everyday challenges that busy bulk handling operations at ports experience.

Improved performance, less spillage, longer equipment life, and easier maintenance all help reduce the labour needed for cleanup. Reducing workers' exposure and access to conveyors means safer operations and allows Transnet to concentrate on other parts of the terminal, improving efficiency and lowering the cost of operation.

CleanScrape® uses a matrix of tungsten carbide wear tips lightly tensioned across the discharge pulley in a three-dimensional helix shape.

The low-profile design of CleanScrape® makes it ideal for situations where access is difficult and space is limited.

Martin's SQC2 Secondary Belt Cleaner features a unique slide-in/-out assembly for safe and easy blade replacement.

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, emphasizing 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, utilizing 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 minimize impact while maximizing 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 visualizing 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 prioritizing 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 optimized 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 prioritized 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 finalized 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 standardized 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 standardized 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 utilization.

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 emphasizes intelligent and green mining practices, integrating modern technologies to enhance safety, reduce environmental impact, and optimize resource utilization.

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 optimizing 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 minimize 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 emphasize 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.

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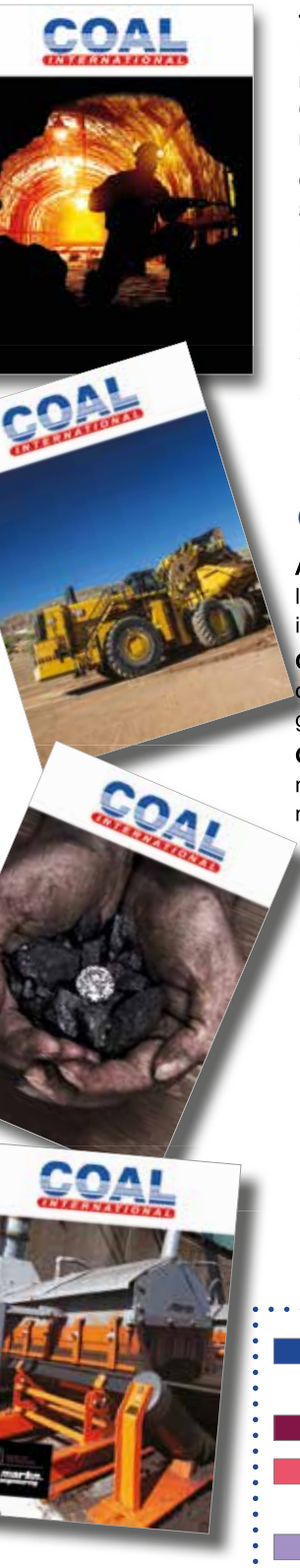

Overview

Tradelink Publishing's flagship publication, Coal International is probably the oldest English language coal magazine in the world. Established in 1858 as the Colliery Guardian, it is distributed to an international database of mining professionals involved in the buying cycle that include:

Operating companies
Senior management i.e. CEO, CFO and Directors
Procurement departments
Mine managers
Mine Electrical Engineers
Mine Mechanical Engineers
Safety and sustainability departments

Coal International expanded to become an international publication when the UK's coal industry was privatised in the mid – 1980s.

We understand your need to get your marketing message out to the intended audience, *Coal International* is regarded as the worlds No 1 publication serving the Coal Industry for equipment suppliers and service companies. With over 180,000 mining professional contacts on our database this publication truly reaches a worldwide audience.

- Digitally Published six times a year
- For our attendance at Major mining exhibitions *Coal International* will be printed and distributed from our stand and can also be printed in a variety languages
- Besides a wealth of feature and technical articles, site visits and industry news, Coal International also covers health & safety, sustainability, technological innovation and financial news, alongside new products & equipment in every issue covering both underground and surface operations.

Coal International topics to be covered throughout the year 2025

Advancements in Clean Coal Technology: Exploring the latest innovations aimed at reducing the environmental impact of coal mining and usage.

Global Coal Market Trends: Analyzing shifts in coal demand and supply, with a focus on emerging markets and geopolitical influences.

Coal Mining Automation: The rise of autonomous machinery and its impact on productivity and safety in coal mines.

Carbon Capture and Storage (CCS): Evaluating the effectiveness and future potential of CCS technologies in mitigating climate change.

Health and Safety Innovations: New strategies and technologies to improve worker safety and health in coal mining operations.

Coal's Role in Energy Transition: How coal can fit into a sustainable energy future, including hybrid energy systems and coal-to-liquid technologies.

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Digital product	Total cost	Total cost for all 6 issues	Digital product	Total cost	Total cost for all 6 issues
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Double page centre spread	£2,500	£12,500	**Article placement in Coal International**	£1,200p/p	POA for multiple pages
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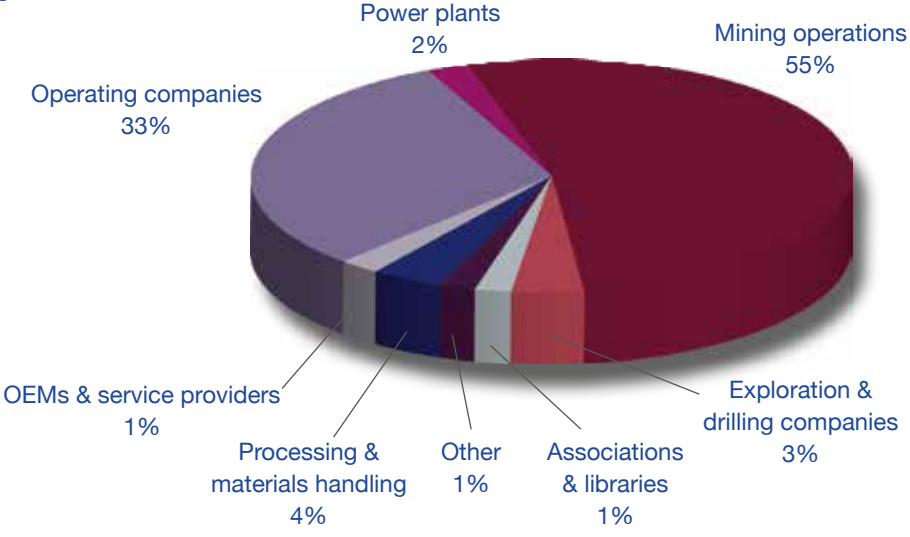


Others include - smelters, steel processes and PR companies

To advertise in *Coal International*, contact
gordon.barratt@tradelinkpub.com

Proposed subjects for Coal International

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

January

- Transitioning to an electric mine
- Autonomous Mining Trucks
- Underground scoop trams
- Underground ventilation systems
- Conveying underground
- Asset management and finance
- Signals and communications
- Continuous miners
- Dust suppression
- Rock reinforcement and ground support

Copy date: 30th January 2025

July

- Wheel loaders and Scoop trams
- Surface and underground conveying
- Crushers
- Sustainable mining
- Underground mining trucks
- Ventilation systems
- Collision avoidance
- Room and pillar
- Continuous miners
- Machine monitoring The IoT

Copy date: 30th July 2025

March

- Hydraulic mining shovels
- Underground crushing equipment
- Underground drilling rigs
- Mining automation
- Crushing and Screening
- Explosives technology
- Lubrication
- Sustainable mining practices
- Longwall systems

Copy date: 30th March 2025

September

- Mining automation and information management
- Underground crushing equipment
- FLP Underground drives
- Scoop trams
- Gas monitoring
- Dozers
- Transitioning mines to sustainable future
- Dewatering pumps
- Health and Safety innovations
- Coals Role in the energy transition

Copy date: 30th September 2025

May

- Pumps and water management
- Rock reinforcement and ground support
- Wheel loaders
- Transitioning to an electric mine
- Conveying
- AFC Stage loader review
- Longwall developments
- Open Pit mining
- Online training solutions
- Big Data and mining

Copy date: 30th May 2025

November

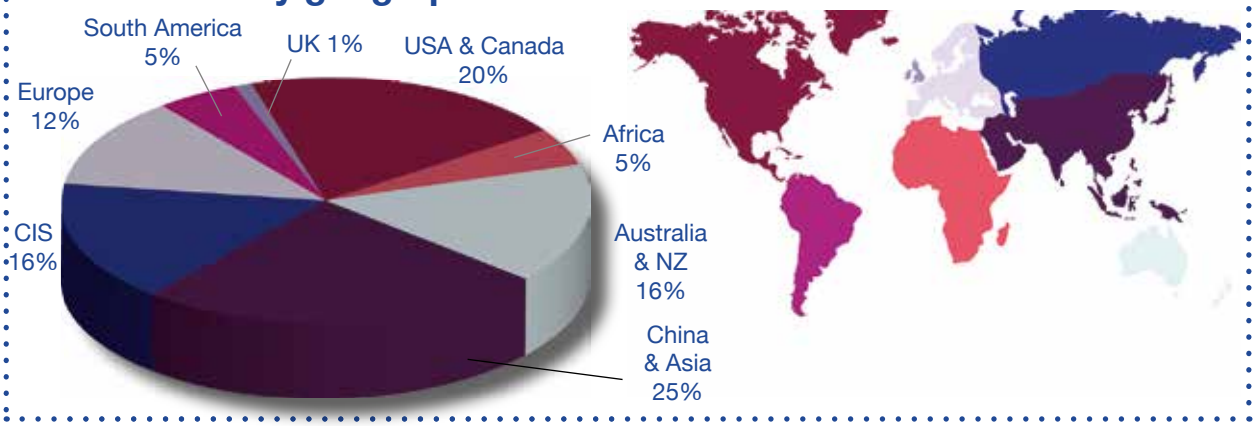
- Hybrid mining machines
- Underground shuttle cars
- Autonomous mining
- Underground conveyor dust suppression
- Screening equipment
- Underground drilling rigs and reinforcement techniques
- Transitioning to a low carbon mine
- Carbon capture and storage
- Shearers
- Draglines

Copy date: 30th November 2025

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

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

Circulation by geographical area









Sustainability in mining: Navigating challenges and solutions

The concept of "sustainable mining" might initially seem contradictory, given that extracting finite natural resources inherently leads to depletion. This article explores the complexities of this term, suggesting that "responsible mining" might be a more accurate descriptor. Since the 1980s, the mining sector has increasingly focused on developing sustainable practices, leading to new terminology and numerous acronyms aimed at promoting better operational standards.

The International Energy Forum highlights the necessity for change, and the mining industry is actively pursuing a greener and more ethical framework. This includes integrating sustainability through strategies such as effective waste management, land rehabilitation, increased use of renewable energy, carbon capture technologies, and other technological advancements.

The strong push towards sustainable mining is evident in initiatives like the European Union's Critical Materials Act (CMA), with recent presentations indicating stricter sustainability regulations for mining operators. Consequently, a wealth of articles and technical papers discuss sustainable mining, encompassing concepts like Environment, Social, and Governance (ESG), stewardship, trust, ethics, shared value, and human rights. Many stakeholders are actively promoting ESG principles and addressing the challenges associated with sustainable and responsible mining.

KEY QUESTIONS REGARDING SUSTAINABLE MINING:

Several fundamental questions arise when considering sustainable mining:

- What are the core principles of sustainable mining practices, and how can their implementation minimise environmental impact?
- How do current mining operations affect local ecosystems and communities, and what measures can be taken to lessen these impacts?
- What role do laws and policies play in fostering sustainable mining practices, and what are some examples of effective regulatory models globally?
- How can mining companies incorporate renewable energy sources and energy-efficient technologies to decrease their carbon footprint?
- What are the challenges and opportunities associated with reclaiming and rehabilitating mined land, and how can companies ensure long-term environmental sustainability?
- How can governments, industries, and communities collaborate to establish and enforce policies that guarantee responsible mining practices and fair distribution of benefits?

GENERAL PERSPECTIVE:

The adage, "If it can't be grown, and it can't be bred, it has to be mined," remains pertinent today. Historically, mining sites were often characterised by dust, pollution, and a lack of aesthetic appeal, as depicted in L. S. Lowry's artwork and historical photographs of UK coal mining regions.

However, post-World War II, attitudes towards the environment and pollution began to shift in the UK. The National Coal Board (later British Coal) initiated programs to rehabilitate spoil heaps. Today, driving through former coal mining areas, the visible signs of past mining are minimal, with reclaimed land now supporting agriculture.

More recent mining developments in the UK have prioritised environmental considerations. For instance, Woodsmith Mine, located within the North York Moors National Park, has developed its processing infrastructure underground, minimising the operation's visual impact wherever feasible.

Similarly, another mining venture is choosing to repurpose a former industrial area for its above-ground facilities.

Globally, numerous mining operations are actively minimising the visual and audible disturbances they create. Routine monitoring of noise, light, dust, vibration, ground movement (subsidence), seismic activity, and other potential sources of nuisance pollution is standard practice, with strict adherence to predefined action levels.

Water management is a critical aspect of both planning and operating mines, especially when water needs to be pumped out of mining areas to maintain production. While local regulations impose strict limits, mining companies often aim to surpass these requirements, diligently monitoring water quality and discharge. Some operations treat the extracted mine water for reuse in their industrial processes or even supply it to local municipalities for residential use.

COMMUNITY AND ECOSYSTEM IMPACT APPROACHES

Engaging with interested and affected parties is a long-standing principle, dating back to the mid-20th century. Many older mining operations have adapted their practices to lessen negative impacts on local ecosystems and communities while actively seeking opportunities to enhance positive contributions, maximising the potential for shared value with all stakeholders.

An Environmental and Social Impact Assessment (ESIA) is a crucial step in evaluating the effects on local communities and ecosystems, but it forms just one component of a broader management strategy. Investigations during these ESIAs can involve advanced techniques like analysing environmental DNA (eDNA) to understand habitat and identify vulnerable species.

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COMMUNITY AND ECOSYSTEM IMPACT STRATEGIES:

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An Environmental and Social Impact Assessment (ESIA) is a crucial step in evaluating the effects on local communities and ecosystems, but it forms just one component of a broader management strategy. Investigations during these ESIAs can involve advanced techniques like analysing environmental DNA (eDNA) to understand habitat and identify vulnerable species. Current best practice includes involving local communities in safeguarding local biodiversity, ecosystem services, and nature-positive aspects of the mining project. The mining industry is increasingly adopting best practices that include community participation in monitoring the environmental and social impacts of mining, including effects on biodiversity and land capability.

Many contemporary mines, particularly in developing nations, have dedicated departments that maintain ongoing communication with local communities. These departments collaborate with the communities to address potential issues before they escalate into significant environmental or health concerns. In other instances, a community relations officer, sometimes through outsourcing, fulfils this role. Experience has shown that effective communication between the community and the mine facilitates the development of appropriate operational adjustments by the mining company.

Operations that fail to comply risk significant negative media attention, overshadowing the numerous operations actively engaging communities in environmental stewardship.

LEGISLATION AND POLICY

Most countries have stringent regulatory frameworks governing the environmental and social impacts of mining. However, the effectiveness of these frameworks hinges on consistent enforcement and uniform application to all

The water treatment facility at a copper mine and processing plant.

mining operators. Unfortunately, this is not always the case in many jurisdictions, making voluntary or industry-led standards potentially more influential in ensuring responsible mining practices.

An example of an industry-led standard is related to mineral reporting. Initial reporting of Mineral Resources according to internationally recognised Codes and Standards necessitates investigations into ESG and related matters. The PERC Standard was among the first to formally incorporate enhanced ESG requirements. The recently introduced Global Industry Standard on Tailings Management is another multi-stakeholder voluntary standard aimed at improving the management of tailings storage facilities (TSFs). Despite such standards, TSF failures continue to occur, often with devastating consequences for communities and the environment.

RENEWABLE ENERGY IN MINING:

Many mining operations, especially those in regions with high solar energy potential, have installed solar panels and associated battery storage systems. Concentrated Solar Power plants could also be considered in suitable locations such as Australia, North Africa, southwest Africa, the Middle East, and parts of South America.

Coal mining operations that utilise methane drainage generate power from gas engines, thereby reducing methane emissions into the atmosphere. While the generated power may not meet the mine's total energy needs, it is used for less energy-intensive activities or supplied to local or national grids for the benefit of local communities. Some mining operations are rehabilitating abandoned or non-functional hydroelectric power generation facilities, often with an agreement with the national government for free power until the rehabilitation costs are recovered. Subsequently, the company is responsible for maintaining the facility throughout the mine's operational life and handing over a fully functional power generation facility to the community upon mine closure.

RECLAMATION AND REHABILITATION

The reclamation of mined land involves various strategies. While complete rehabilitation of metalliferous open pits is generally not feasible, these excavations have found alternative uses, such as being filled with water for recreational purposes. However, the vast open-pit copper mines, particularly in South America, are unlikely to be rehabilitated at all after the extraction of hundreds of millions of tonnes of ore.

China has pioneered an innovative use for an old open-pit mine by constructing a luxury hotel within the remaining void. At the time, a UNESCO representative lauded the hotel as a model for sustainable development. In the UK, Stoke City football ground was built on the former site of Stafford No.2 Colliery, demonstrating another example of converting a mine site for community benefit.

Driving along the M1 motorway between Chesterfield and Wakefield in the UK, the absence of visible mine dumps

Big natural methane gas generator in a power generation unit.

and industrial areas is a testament to successful mine rehabilitation and land restoration efforts that took place in the 1980s. This suggests that the UK was likely a leader in this field at the time.

Other major coal mining regions in Europe and globally have adopted sustainable approaches to prevent the spontaneous combustion of waste dumps and progressively rehabilitate these areas, spreading the associated costs over time. This approach has significantly improved air quality in surrounding communities, with active community involvement in shaping the final land use.

Where coal mining, particularly longwall mining, causes subsidence, as seen in Poland where the ground has sunk by over 50 meters in some areas, measures are taken to protect significant monuments and buildings by preventing mining within their zone of influence. In

Apedale pit wheel memorial and coal tub located in Apedale community park,

Abandoned mining area restoration in Cyprus.

instances where subsidence-induced depressions fill with water, entirely new ecosystems can develop. This has been observed in Poland and Bangladesh, with local communities in Poland expressing a preference for their "new wetland" over the pre-mining agricultural land. In Bangladesh, a "lake" formed by subsidence now supports a new fishing industry and provides irrigation for rice fields.

Locally, beyond the mining museums that dot historical mining regions, such as Chatterley Whitfield in Stoke-on-Trent, former mining sites have found innovative new purposes. The Eden Project in Cornwall, for instance, has transformed a former China Clay quarry into a flourishing biodome showcasing a diverse array of plant life. Similarly, The National Archives utilise the stable temperature and low humidity of the inactive sections of the Winsford Salt Mine in Cheshire for the long-term preservation of important documents. In Edinburgh, Gravitricity is pioneering technology that uses mine shafts to store and release energy to the National Grid, capitalising on the inherent power potential of these underground structures.

Tailings dams also require careful rehabilitation post-operation to ensure their long-term stability. This often involves establishing a protective layer of gravel or rock and reshaping the structure to promote surface water runoff and minimise water infiltration.

Numerous initiatives are underway to accelerate the revegetation of rehabilitated land and waste dumps. These include employing hydroponics, utilising treated mine water for irrigation, researching fast-growing vegetation suitable for rapid ground cover and subsequent incorporation as organic matter, planting and irrigating trees, facilitating the return of wildlife, and creating wetlands, which naturally support the re-establishment of diverse native plant and animal species.

ENFORCING SUSTAINABLE MINING POLICY:

Regrettably, some mining operations will invariably prioritise profit over environmental protection, health and safety, and community engagement. These instances often dominate media headlines and tend to occur in countries with less political stability. However, numerous successful collaborations exist between local and national governments, communities, non-governmental organisations, professional associations, and educational institutions to develop responsible mining projects. These projects aim to benefit the community through employment and the provision of services and goods, minimise environmental impact during operation and ensure ongoing adherence to environmental standards, and contribute to the country through taxes and royalties. Such collaborations foster innovative approaches to managing the impacts of mining, paving the way for a more sustainable future for the areas surrounding the mines.

This need for ongoing cooperation extends long beyond the life of the mine, and once mining has ceased, a certain amount of stewardship is still required. In the UK, there is the Coal Authority, which continues to be involved with the mining industry, supplying information (where available) relating to old workings, shaft locations, discard dump and TSF locations, and any other matters relating to the historical issues associated with mining. The Coal Authority, according to the UK government website, makes a better future for people and the environment in mining areas. The Coal Authority is an executive non-departmental public body sponsored by the Department for Energy Security and Net Zero.

Future outlook for sustainable mining In Europe and many other parts of the world, mining has a bad press, and anti-mining activists try to prevent mining, without which we would not be able to have the luxuries that are taken for granted: Mobile phones, electric cars, solar panels, electricity, mass-produced designer clothes, efficient agriculture – the list can be extended ad nauseum, ad infinitum!

Many mining companies and projects operate and develop responsibly with a focus on sustainability and a long-term view of leaving a positive legacy. Back to the adage mentioned earlier, ‘if it can’t be grown, and it can’t be bred, it has to be mined.’ The IOM3 are involved in recognising excellence in sustainable resource management and protecting and enhancing biodiversity, water, air, and soil through the Sustainable Future Awards initiative.

The mining of metals industry is transforming to meet the rising demand for essential materials in electric vehicles, agriculture, construction and power infrastructure while addressing climate and geopolitical challenges.

Innovations in Bale mining, automation and circular practises are reshaping mining operations, improving environmental impact and operational efficiency, and emphasising resource stewardship. Collaborative efforts across sectors, alongside supportive policies and investment, are crucial in redefining the mining industry's role from extraction to a responsible, essential resource provider in the global economy. The industry must take the lead to seize this opportunity.

Agriculture, the future of mobility and the rise of artificial intelligence connected. Unsurprisingly, the answer is through the materials that make them possible. Demand for minerals like steel, copper, phosphates And aluminium is surging, driven by their use in vehicles, advance agriculture, construction, power technologies and other critical industries. The mining and metals industry, often seen as one of the most traditional industries, is undergoing a multi-dimensional transformation to meet the demands of a growing global economy, while addressing urgent challenges such as climate change and geopolitical disruptions.

The industry's reaction to rising demand presents a chance for mining and metals to play central roles in sustainable innovation, resource management and global advancement.

METALS FOR MOBILITY

How mining can meet electric vehicle demand and support the energy transition

The mining of metals industry hasn't traditionally been recognised as innovative. The industry's technological innovation has been marginal, process orientated, usually motivated by cost reduction, and, more recently, aimed at enhanced environmental performance, the though not radically transformative. However, recent examples show that this might be changing. According to the world intellectual property organisation the number of mining related patents presented from 2006 to 2018 increased by 41% compared to the period of 1970 to 2005, emphasising and increasing interest in innovation in the industry.

This growing interest is also reflected in the rise of open innovation initiatives, which use external knowledge and technologies to accelerate the development of new ideas in the industry. Companies are also making organisational changes to integrate in innovation into their regular operations, the World Economic Forum for example introduced an open innovation challenge for mining in 2024.

With over 100 solutions emerging from various startup Sunday universities, all contributing new knowledge to transform industry operations, it's clear that many exciting initiatives are underway.

Furthermore, there has been a notable rise in more radical innovations that could disrupt and structurally change the industry, driven by progress in information technology and AI..

Automation and machine learning (ML)

Automation and machine learning are pushing the industry beyond traditional expectations. Recent innovations in the industry are automated mining operations, ranging from autonomous trucks and drone surveys to AI for predictive maintenance and optimisation of resource extraction. These solutions have enhance safety and efficiency in operations. Should these technologies continue to advance at the same pace we're seeing in other fields we could witness a wholly transformed mining and metals industry and the related activities along the value chain.

The expanding use of bio mining [the Press of using microorganisms to extract metals from also mine waste], nature-based solutions, atomisation and machine learning are advancing the industry beyond what was traditionally imagined. Although bio mining was introduced over 60 years ago, a more than 20% of the world's copper production is currently extracted using microbes or bio leaching. These technologies are now evolving faster and could have a greater impact on what we know about mining, especially unlocking value for those low-grade deposits that were not economically viable decades ago.

For context, leeching extracts valuable metals from all by dissolving them in a liquid solvent [usually chemical solutions], breaking down metal compounds while carrying the dissolved metals. This shift away from traditional approaches will involve replacing chemical solutions [often containing cyanide or sulfuric acid] with living organisms.

In general, the latter pose fewer environmental risks, reducing energy consumption while recovering a higher quantity and variety of minerals, including metals not previously targeted for extraction. Samples of new technologies being explored include using plants capacity to concentrate minerals and extracting minerals from a variety of sources.

The numerous alternative solutions currently in development highlight the industry's ongoing transformation and the potential disruptions that could impact efficiency, profitability and compliance with regulations. However innovation is a journey, and some challenges remain:

Many solutions still need to be developed into commercially viable process is more importantly they need to be implemented on a broad scale to make real impact.

Looking ahead, the mining and metals industry should shift its focus from isolated technological advancements to integrated, solutions-based approaches. By promoting collaboration, the industry can drive deeper, systemic transformations to address broader sustainability challenges.

Finally, the industry and its ecosystem must keep pushing for creative solutions. Building greater trust among stakeholders, including academia, the private and public sectors, and the financial industry, will be key to success.

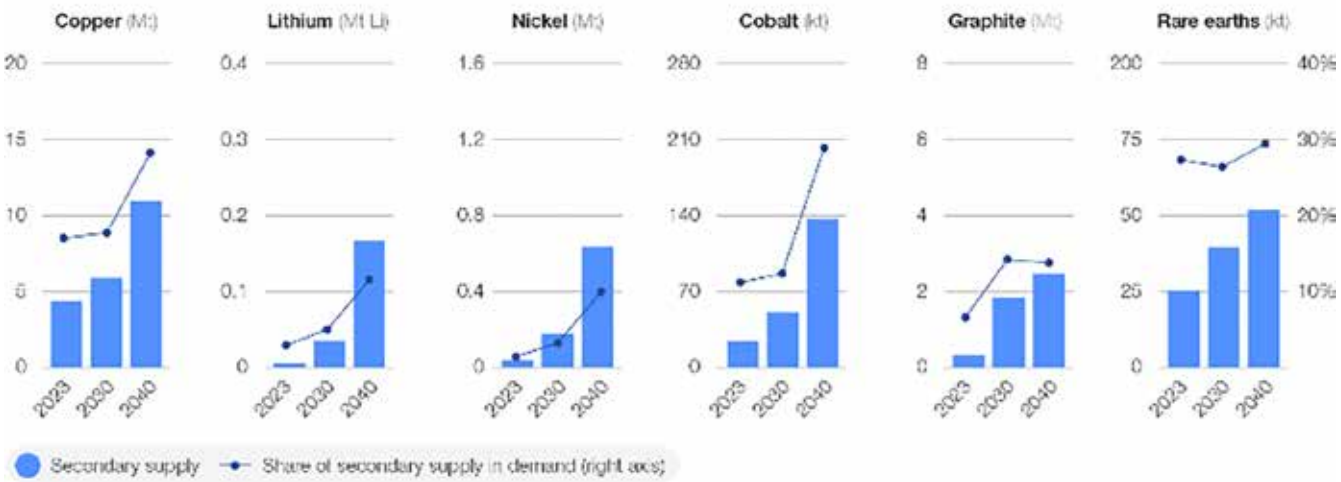
Innovation can disrupt the mining industry. These sustainable startups are leading the way although the industry is on the right track, more momentum is needed, and there's plenty of curiosity about what might unfold in the near future.

From extraction to long term resource stewardship

Mining and metals companies are embracing new responsibilities beyond extraction and refining, which are conventionally at the industry's core. For example, the industry has expanded its traditional capacities, moving

Secondary supply from recycling plays an increasingly crucial role in meeting demand growth in climate-driven scenarios, particularly after 2030

Secondary supply volumes and share of total demand for focus minerals in the NZE Scenario



towards recycling and incorporating nature positive principles. This could redefine the industry's role along the entire value chain-not just as providers, but as stewards of the resources that fuel sustainable technologies and enable industries worldwide. It would also reinforce the idea that metals and minerals can continually contribute to the global economy.

Mining companies are now embracing Recycling process is, facilitating the re-introduction of metals into the supply chain and enhancing opportunities for secondary use. With knowledge of metals that can be recycled almost infinitely, the industry is not only well positioned to lead but has a competitive advantage. Some companies have already entered the business-examples include the development of new recycling capabilities and partnerships with key stakeholders to enhance the recycling process and create closed loop solutions.

Arcelor Mittal and new Co are among the companies with experience in steel recycling. Companies like Rio Tinto our establishing closed loop recycling systems and installing in-house capacity to recycled post-consumer aluminium scrap. At the same time valley SA is starting to deliver production via circular process is in their operations in Brazil unveiled base metals it's starting to offer circular solutions to customers downstream. Glencoe and SQM are moving towards battery recycling, and other companies like Anglo American, Norsk Hydro, Johnson Matthey and Arbus are also leading the way in the recycling of metals. Recent regulations, like the critical raw materials act, are incentivising companies to embrace circularity. This act sets a target for the EU's recycling capacity to cover at least 15% of the annual consumption of each strategic row material by 2030. Strong steps towards a comprehensive incorporation of circularity principles for metals and increasingly important in a world where electronic waste [which contains various valuable metals closed bracket is the fastest growing waste category.

Additionally, mining and metals companies are increasingly introducing land and water restoration, renewable energy, an ecosystem health strategy, and adopting principles at prioritise nature. The World Economic Forum is developing guidance to help mining companies deliver positive biodiversity outcomes. This guidance showcases examples of practises and solutions that businesses can adopt with within mining operations across landscapes, the value chain UN systems. Furthermore, understanding the economic value of environmental assets an ecosystem services- such as freshwater, carbon sequestration and flood protection- and incorporating this into business decision-making could strengthen the business case for action on nature.

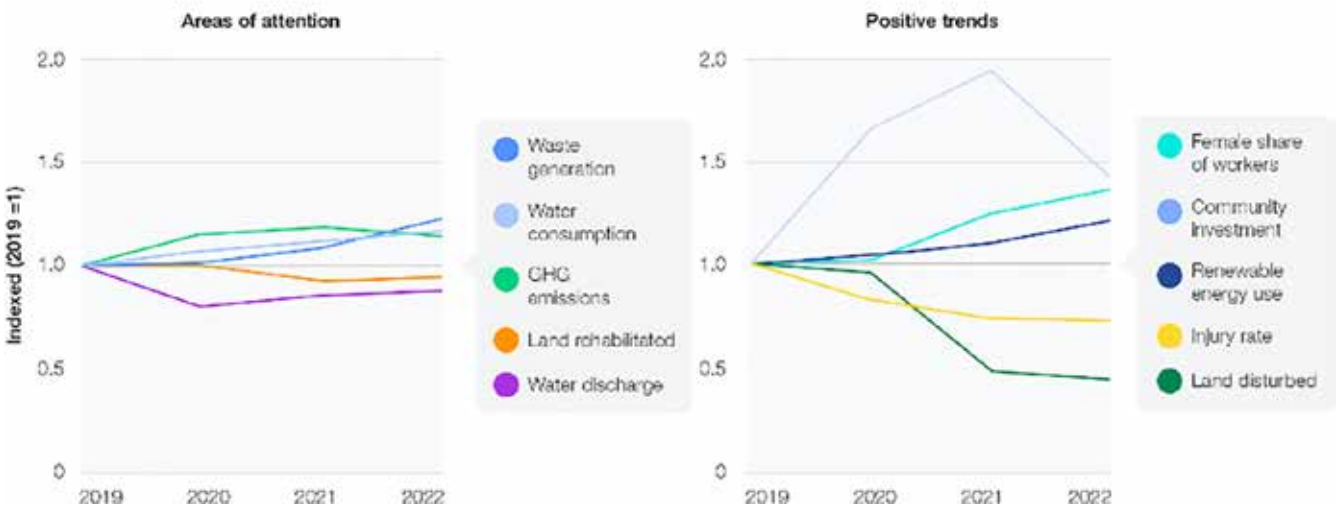
The industry should ensure the responsible management of minerals and metals throughout their entire lifecycle. Moving forward the industry must take clear steps to position itself as a resource steward.

Investing in end-of-life material recovery technologies and working with manufacturers and recyclers could help mining firms and show that metals are continually re processed. This would reduce the demand for new extractions and lower environmental impacts.

The circular economy requires more than just recycling and there is still significant room for improvement in incorporating circularity principles in mining operations to reduce waste. Beyond recycling, designing for circularity is an area with significant untapped potential. More importantly, a change in mindset along the value chain will be needed to advance circularity practises and advancer to faster pace. There is a business case, and the mining industry should take the first step.

Decarbonising the value chain and meeting emissions reduction targets through cleaner energy technologies and energy efficiency will be crucial.

Sustainability reporting paints a mixed ESG picture, with substantial room for improvement
Selected ESG indicators, 2019-2022



Source: World Economic Forum

Resource stewardship requires inclusive development and a more comprehensive approach. Larger companies, in collaboration with governments and stakeholders, can help address the unique challenges of artisanal UN small scale mining, promoting a more inclusive and sustainable mining ecosystem.

Adapted from International Energy Agency(IEA)

Progress in these approaches must come from a business case that will yield results in higher market share, environmental, social and governance recognition on revenues. Some innovations mentioned in the previous section will also help the industry move in this direction. As more miners engaging initiatives beyond primary extraction, the industry as we know it might be transformed, from folks in on extraction to playing a leading role across the entire materials value chain.

Charting A sustainable path forward for mining and metals to drive the meaningful transformation towards technological disruption and resource stewardship, the mining and metals industry must harness a range of key enablers- from forward thinking policies and robust regulatory frameworks to collaborative partnerships, innovative business models and strategic capital allocation. This transformation unfolds within a global context marked by geopolitical shifts, You later re pressures, community expectations and environmental challenges, making adaptability and resilience essential.

How metals can help construct more sustainable cities around the world implementing technological innovations, increasing recovery of metals in a full transformation won't be achieved by escalating individual efforts. Collaboration is shaping how innovation penetrates the industry. More joint efforts to scale new technologies are increasing project level benefits and enabling the industry to better address both economic and environmental challenges on a global scale. Increasing collaboration between mining companies and technology providers has escalated to develop solutions for targeted problems. For instance, BHP and Rio Tinto have partnered to expedite the first trial of Komatsu and caterpillar's battery electric haul truck technology in 2024.

Amid potential mineral shortages and supply chain disorders joint ventures or vertical integration have also proven effective for managing risk on large scale projects.

Collaborations along the value chain have also increased. Offtake agreements have underscored the importance of mineral provenance to a downstream industry. Integrated approaches across the supply chain can streamline process is and enable more precise demand planning. Automotive companies such as Mercedes-Benz, BMW and Volkswagen for instance are securing long term supplies of battery minerals and other essential materials and sending demand signals for cleaner products. Meanwhile, agricultural partnerships are customising mineral solutions to support sustainable mining practises. Tech companies, 2, are prioritising secure access to both minerals and power source is crucial to their operational resilience.

Forward thinking policies and robust regulatory frameworks

Policies and regulations play a key role in shaping and enabling the industry's transformation. Governments are increasingly adopting a more active and forward-looking role in the minerals market. Many have enacted new policies aimed at enhancing regulations, improving access to resources, and bolstering infrastructure and development, all of which significantly influence industry operations. Leading policies like the inflation reduction act, the critical raw materials act and the chips and science act of enhancement minerals supply security-many strategies worldwide reflect a heightened awareness of critical minerals strategic importance for countries and governments. Between 2020 and 2022 alone more than 100 new policies were passed, reflecting the growing recognition that policy intervention is necessary to meet the demands of the energy transition, both sustainably and responsibly.

However, more policy support will be needed to decarbonise the industry. Collaboration between companies and governments could also be encouraged to develop projects. Engaging with governments and policymakers underscores the mining and metals industries commitment to gaining wider support and adopting a more collaborative approach to its role. Through these partnerships, the industry might help shape policies for sustainable development, ethical sourcing and emissions reduction, creating lasting benefits that reinforce its role as a vital force for positive societal impact.

STRATEGIC CAPITAL ALLOCATION AND FINANCE

Evolving stakeholder expectations, resource scarcity and climate concerns are driving the shift towards sustainable finance – and the mining and metals industry is no exception. Financing strategies for mining projects are undergoing a transformation to support projects that deliver positive impacts, long-term sustainability and financial returns. As a capital-intensive industry, mining requires substantial additional investment to meet these evolving demands. To satisfy the rising global demand, annual investments ranging from $300-400 billion will be needed until 2030. It’s no surprise, therefore, that capital is the most prominent risk reported by seniors in the industry, reflecting increased scrutiny from investors and challenges of accessing sustainable finance.

To address these challenges and drive sustainable growth in the sector, innovative financing models that integrate diverse funding sources and actively involve multiple stakeholders will be crucial. While the traditional financial ecosystem will keep playing a role, given the local impact of mining, more local and regional financiers will be critical in bringing capital into the industry. For instance, multilateral development banks and governments are becoming key to derisking investments through guarantees and support for value chain activities, making mining projects more attractive to investors. Finally, international investors will be key to providing liquidity and flexibility, ensuring the mining industry has access to scalable and adaptable funding sources.

LOOKING FORWARD

The "go-together" approach needs to gain more momentum across the industry, cultivating the resilience, accountability and productivity needed to meet evolving expectations. As we look towards a world that increasingly demands both sustainability and technological advancement, the mining industry is poised to transform far beyond traditional extraction and processing. Evolving from simply a source of raw materials, the mining and metals industry must become a secure, responsible provider of critical resources, collaborating across sectors to address urgent global challenges in climate, energy, agriculture and infrastructure, among other areas. By advancing environmental and social responsibility, the industry can create a productive and responsible future, positively influencing socioeconomic systems around the world.

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This vision redefines the industry as more than a step in the supply chain; it becomes a foundational pillar of global progress. Mining has the power to uplift communities, create jobs and encourage partnerships in underserved regions, setting standards for resource management and environmental stewardship. As the world moves towards low-carbon energy, smarter cities and sustainable food systems, mining can lead by example, championing a collaborative, resilient and sustainable future where industry progress aligns with the needs of society and the planet alike.

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Remote longwall operations and the future of sustainable mining

Technological advancements in mining have undergone continuous evolution, leading to significant changes in mining techniques, equipment, and overall productivity. Recent innovations have primarily focused on improving communication systems, automation, and data utilization to enhance the health and safety of miners, as well as to optimize operations. While coal extraction remains vital for industries such as energy, steel production, and transportation, mining methods continue to present challenges, including inefficiency and environmental impact.

Over time, longwall mining has emerged as a safer, smarter, and more efficient method for coal recovery. Remote and autonomous mining technologies have transitioned from specialized techniques to becoming key players in the market. This transformation was accelerated by the COVID-19 pandemic and subsequent lockdowns, which increased the need for mine operators to maximize efficiency amidst economic pressures. Furthermore, there is a growing emphasis on environmental, social, and sustainability issues, which are currently central to discussions in the mining industry.

These combined pressures are driving the industry to innovate further, pushing the boundaries for modernizing mining practices to reduce environmental impact while striving for more economically viable solutions. *Gordon Barratt of Coal International discusses some of the positive aspects of longwall mining and the technological advancements transforming the industry.*

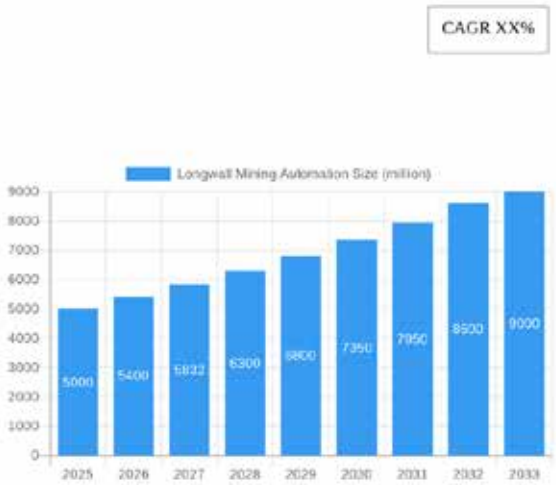
The basic idea of longwall mining was developed in England in the late 17th century, although it may have been anticipated in the pre-industrial era by a similar technique utilised by the Hopi of Northeastern Arizona in the 14th century. Miners undercut the coal along the width of the coal face, removing coal as it fell, and used wooden props to control the fall of the roof behind the face. This was known as the Shropshire method of mining. While the technology has changed considerably, the basic idea remains the same, to remove essentially all of the coal from a broad coal face and allow the roof and overlying rock to collapse into the void behind, while maintaining a safe working space along the face for the miners.

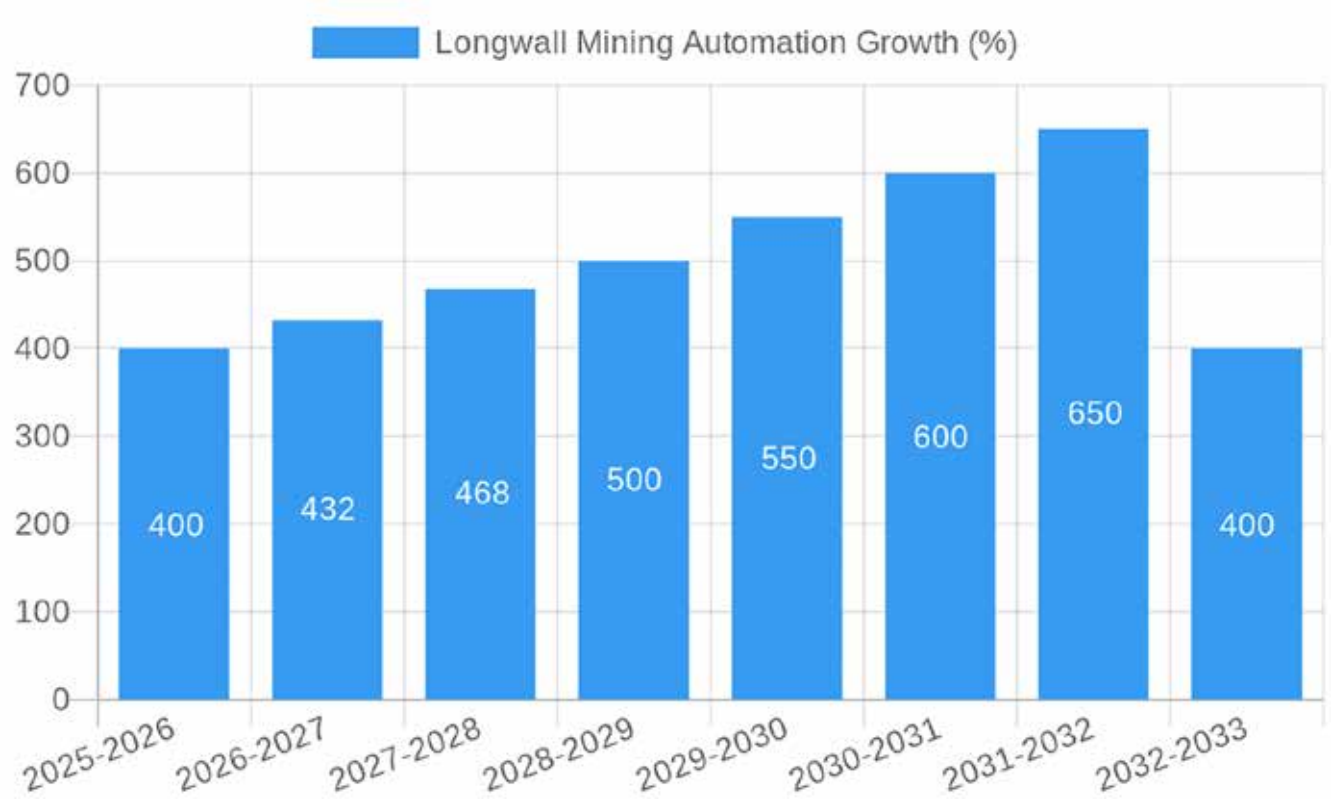
Starting around 1900, mechanization was applied to this method. By 1940, some referred to longwall mining as "the conveyor method" of mining, after the most prominent piece of machinery involved. Unlike earlier longwall mining, the use of a conveyor belt parallel to the coal face forced the face to be developed along a straight line. The only other machinery used was an electric cutter to undercut the coal face and electric drills for blasting to drop the face. Once dropped, manual labour was used to load coal on to the conveyor parallel to the face and to place wooden roof props to control the fall of the roof.

The longwall method can extract high percentages of the available coal seam (typically 80%) compared to other techniques, such as room and pillar mining (typically 60%). As a result of this efficiency, longwall mining for coal accounts for almost half of all underground mining operations.

The longwall mining automation market is surging forward, fuelled by a rising need for safer, more productive, and more efficient coal extraction. Currently valued at around $5 billion in 2025, the market is anticipated to grow at a compound annual growth rate (CAGR) of 8% between 2025 and 2033, reaching an estimated $9 billion by 2033. Several key factors are propelling this expansion. For one, the inherent hazards of underground coal mining are

Longwall Mining Automation Leading Players





compelling operators to embrace automation to minimize risks and boost worker safety. Furthermore, the increasing complexity and depth of mining operations necessitate more efficient and precise extraction techniques, areas where automation truly shines. Lastly, the global movement towards sustainable mining practices is driving the demand for optimised resource utilisation, a goal directly supported by automated systems that cut down on waste and maximise output. Fully automated systems are capturing a substantial portion of the market thanks to their advanced capabilities, although semi-automated systems remain important, especially in regions with limited upfront investment capacity.

Geographically, the market is segmented, with North America and Europe currently holding significant shares. However, the Asia-Pacific region is projected to experience the most rapid growth, driven by the swift expansion of coal mining activities in nations like China and India. Major players such as Komatsu, Caterpillar, and others are actively investing in research and development and forming strategic alliances to strengthen their market positions and capitalize on emerging opportunities. Despite this promising growth, some challenges persist, including the considerable initial costs associated with automation, the necessity for skilled workforce training to operate and maintain these systems, and potential technological disruptions and integration complexities within existing infrastructure. Nevertheless, ongoing technological advancements and increasing government backing for the adoption of automation technologies are expected to lessen these obstacles and further propel market growth throughout the forecast period. Beyond coal mining, longwall mining automation is finding increasing applications in areas like emergency rescue and other specialized mining operations, contributing to the overall diversification of the market.

LONGWALL MINING AUTOMATION CONCENTRATION AND CHARACTERISTICS

Currently valued at $ 5 Billion in 2025, the longwall mining automation market exhibits significant concentration, especially among key players such as Komatsu, Caterpillar (Cat), and FLSmidth. Their extensive background in both mining equipment and automation technologies provides them with a strong competitive advantage. Innovation in this space is marked by the incorporation of artificial intelligence (AI), machine learning, and sophisticated sensor technologies aimed at boosting efficiency, safety, and overall productivity.

Areas of Concentration: Automation solutions are primarily focused on shearer guidance, roof support control, and haulage systems.

Characteristics of Innovation: The emphasis is on predictive maintenance, autonomous operation, and real-time data analytics to optimize resource allocation.

Impact of Regulations: Strict safety and environmental regulations are a key driver for the adoption of automation, as it helps reduce human risk and environmental impact.

Product Substitutes: Direct substitutes for longwall mining automation are limited. However, alternative mining methods, such as room and pillar mining, present indirect competition.

End-User Concentration: Large-scale coal mining companies, particularly those in Australia and China,

constitute a substantial portion of the market's customer base.

Level of M&A: The market has experienced a moderate level of mergers and acquisitions (M&A), with larger companies acquiring smaller, specialized automation firms to broaden their range of offerings.

LONGWALL MINING AUTOMATION TRENDS

The longwall mining automation market is on a strong upward trajectory, primarily propelled by the growing need for enhanced safety, productivity, and operational efficiency within coal mining. The global emphasis on sustainable mining practices provides further impetus to this market's expansion. The incorporation of autonomous systems, leveraging advanced analytics and machine learning, is revolutionising the industry by significantly reducing the need for human presence in dangerous settings. This trend is amplified by rising labour expenses and a shortage of skilled workers in the mining sector. Moreover, automation's capacity to optimize resource extraction, thereby minimizing waste and maximizing yield, stands as a significant catalyst for its adoption. Companies are increasing their investments in research and development, with a particular focus on refining sensor technologies and sophisticated control algorithms, to further enhance the capabilities of automated systems. Looking ahead to the forecast period (2025-2033), these technological advancements are anticipated to lead to improved safety records, substantial cost reductions, and heightened efficiency, all contributing to the market's significant growth, projected to reach $ 9 Billion by 2033. The preceding historical period (2019-2024) demonstrated a consistent increase in adoption rates, establishing a solid groundwork for the anticipated exponential growth. The current year (2025) represents a pivotal moment, as fully automated systems achieve broader acceptance, propelling the market into a new era of rapid expansion.

KEY REGION OR COUNTRY & SEGMENT TO DOMINATE THE MARKET.

The fully automated segment is poised to take the lead in the longwall mining automation market. This dominance is fuelled by significant technological progress and a strong industry-wide push for enhanced safety and productivity. Experts predict that fully automated systems will experience a more rapid growth rate compared to their semi-automated counterparts.

DOMINANT SEGMENT: FULLY AUTOMATED SYSTEMS

Reasons for Dominance: Fully automated systems offer compelling advantages in terms of efficiency, safety, and reduced operational costs when compared to semi-automated options. The declining costs of sophisticated technologies, including artificial intelligence (AI) and robotics, are making fully automated solutions increasingly accessible and economically viable. Furthermore, the growing emphasis on stringent safety standards within the mining sector is a critical factor driving the widespread adoption of these advanced systems. The increasing focus on leveraging data for informed decision-making and implementing predictive

Automated Plow System

Coal Shearer

maintenance also provides a strong incentive for companies to invest in fully automated solutions.

Key Regions: Australia, China, and the United States are projected to be major contributors to the overall market growth. This is attributed to their significant coal reserves and ongoing investments in automation technology.

Longwall Mining Automation Product Insights: The market features a diverse range of products, including automated shearers, roof support systems, and haulage systems. These systems are equipped with advanced sensors, sophisticated control systems, and specialized software designed to optimize operations and enhance safety protocols. A key trend in product development is the integration of AI and machine learning capabilities, which enables predictive maintenance and real-time operational adjustments to maximize efficiency and minimize downtime. This integration translates to substantial cost savings and improved resource extraction. The industry's focus is also shifting towards the development of modular and adaptable systems that can be seamlessly integrated into existing mining infrastructure.

LONGWALL CUTTING MACHINES AND MINING METHODS.

Choosing the right machine, particularly the shearer, is critical for achieving a high concentration of extraction from a given longwall. This is increasingly important due to rising mining costs and the increasing depth of coal seams.

Analysing the mining process, especially in challenging environments, reveals that determining the coal's properties that significantly affect the mining process is crucial for defining the operational range of a drum longwall shearer. These properties also influence the technique, technology, and overall effectiveness of mining, directly impacting the performance of the machines. Consequently, the selection and design of cutting heads should be based on these factors, along with any anticipated performance outcomes.

The coal shearer is a more complex machine in comparison to the plough which is nothing more than a blade like solid block segments fitted with picks. The plough is pulled across the face with chains powered by motors mounted at one end of the face.

PUNCH LONGWALL MINING

The aim of this method is to mine coal form the highwall of an open cut operation, in which the stripping ratio is far outweighs the production cost of coal mined.

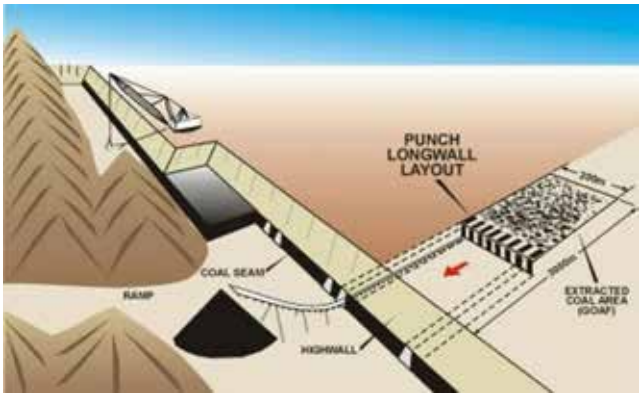
The method consists of driving a set of headings in to the coal seam from the highwall of an open cut operation. The two headings are driven a predetermined distance (say 3 000 m) and are then connected to form a panel. Longwall face equipment is subsequently installed across the panel as shown in **Figure 1**. The coal is mined by retreating back toward the highwall until a short distance from the entry. This section of coal is left to act as a barrier pillar to protect the highwall.

Punch longwall mining is carried out using single entry gate roads as the they are only used by one panel. The adjacent panels can be similarly extracted with fresh entries being driven adjacent to the previous mined out panel leaving a barrier pillar of suitable width to provide safe retreating of the new panel as shown in Figure 2 opposite.

The extracted coal is transported out and piled at the ramp where it is transported by the most convenient method used by the mine.

This system of mining is suited to mining reserves which would otherwise will be difficult to mine with the conventional mining methods.

The features of this system of mining include:



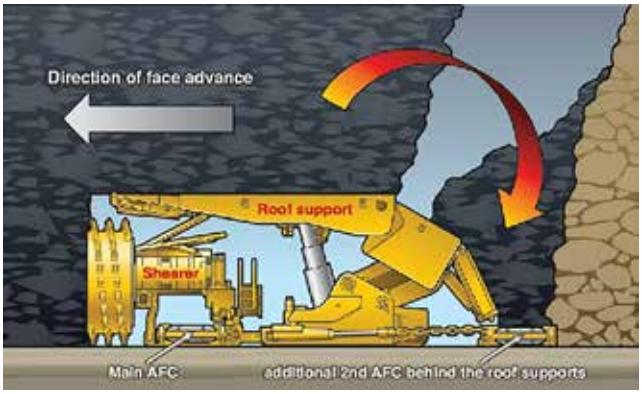
Punch Longwall

- The system requires no transport, conveyor drifts, shafts, complex ventilation systems or main headings as in conventional underground mining methods, hence this benefit provides cheaper, faster, simpler access and commencement of longwall mining.
- Gaining knowledge about mining, geological, and other information is quickly achieved at an early stage.
- This method is flexible as the infrastructure can be easily relocated.
- The development of gate roads on future panels is separate from the current longwall panel due to the use of barrier pillars.
- Requires less workforce and the method is suitable for contract work.

TOP CAVING

Longwall Top coal Caving (TCC) is a method of extraction for underground mining of thick seams. It uses a longwall set-up and natural forces to aid in the winning of coal. With this method of extraction only a single longwall is developed at the foot of the seam. The control of the roof layers at the face is by means of powered supports. At the face, the coal is mined with a Shearer at a set height and transported out of the mine using an armoured face conveyor (AFC). According to the rate of advance, the upper coal section of the seam is then induced to cave at the goaf side and is removed by a second AFC, which is situated behind the face supports.

The space behind the rear legs of the powered supports is large enough to allow lateral and vertical movements of the goaf shield for control of caving. At the beginning of the operation of the TCC (i.e., at the end of the machine pass) when the face conveyor and supports are advanced, the rear conveyor is still protected by the goaf shields. The goaf shields are then retracted to direct the drawing off of the caving coal onto the rear conveyor. Controlled drawing contributes decisively towards a highly satisfactory rate of recovery. The canopies should be provided with openings in case caving has to be initiated by shot firing.

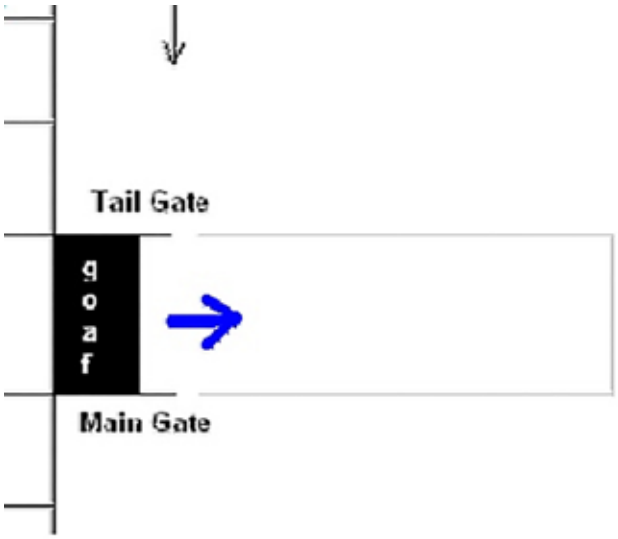


Longwall Top Coal Caving

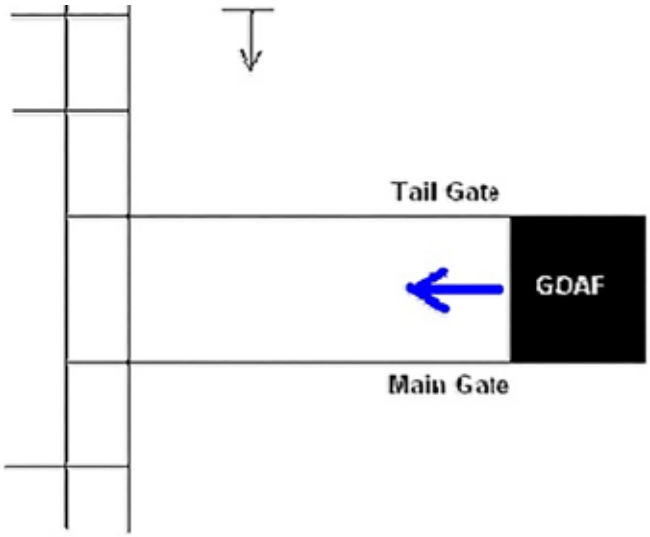
In order to use the TCC method successfully, the coal should part readily from the roof. In cases of sticky coal, TCC in two lifts should be applied. First, a longwall face is developed at the horizon of the seam. After that, a second longwall face is developed at the floor horizon of the seam, and the coal remaining between the two faces is recovered by caving. Thick seams can be almost completely extracted using this method.

Another variation of the TCC use, where the seam thickness is over 15m and the flow and parting characteristics of the coal are suitable, is “The Velenje Vertical Concentration” method .

Two longwall faces are again developed. The top slice is placed so that there is 5m of coal left above the supports. This top slice is advanced as an ordinary longwall operation, leaving 5m of coal overhead. The overhead coal is allowed to cave with the roof and so, is preliminarily broken. A second longwall face is then started off (6-12 months later) at the foot of the seam, using the basic TCC system. Between the upper and lower galleries is a septum perhaps 5m deep. Due to the caving of the coal from the septum and the previously broken overhand coal, rapid winning of coal is made possible in the lower gallery using this method, and where conditions allow, the mining losses are also reduced. Because of the rapid



Longwall Advancing Method



Longwall Retreating Method

evacuation of the broken coal from the overhand part of the seam, Achan (1979) reports that output man shift reached the high value of 90-100 tonnes per man shift.

The viability of these methods depends greatly on the flow characteristics of the caving coal. If it tends to large blocky fractures, it is unlikely the method will be successful. The major advantages of these methods are the possibility of a very low cost per tonne of Run of mine coal, high productivity, and a high percentage of recovery.

LONGWALL RETREAT MINING

The predominant method of longwall mining in Australia is longwall retreat system. In retreat longwall mining, two sets of entries are driven between 100 to 250m apart. When the entries have been driven a predetermined length, say two kilometres, they are connected, and a rectangular longwall block is outlined. The longwall face is then installed and as mining continues into the panel, back to the original development, the entries are allowed to collapse behind the face line to form part of the goaf. The gate entries are known as main gate and tail gate. Generally, the main gate contains the belt conveyor and the pantechnicon for facilitating power and logistics to the longwall face.

LONGWALL ADVANCE MINING

An alternative method of mining is advance longwall mining. In longwall advancing, the longwall face is set up a short distance from the main development headings. The gate entries of the longwall face are formed as the coal is mined. The gate roadways are thus formed adjacent to the goaf. Normally the gate roads are protected from the goaf by a line of packs, which are built to provide protection to the gate roads and minimising excessive circulation of air between the gate entries through the goaf. The gate entries are known as main gate and tail gate. The gate roads servicing an advancing longwall panel are single entries and each coal panel is separate from the adjacent workings with a solid barrier pillar, whose width is dependent upon the depth of the working. Generally, the main gate contains the belt conveyor and the pantechnicon for facilitating power and logistics to the longwall face. A typical advancing panel layout can be seen opposite.

LONGWALL MINING: EFFICIENCY, CHALLENGES, AND THE FUTURE

Advantages and Global Application:

- Longwall mining enables the extraction of coal from deep seams inaccessible to surface mining, vital for nations with substantial underground coal reserves.

- Its efficiency and safety features make it a preferred method in major coal-producing countries like the USA, Australia, and Germany.

- In India, there is a push to increase longwall mining to boost underground coal production, aiming to mitigate environmental and socio-economic issues associated with opencast mining. Singareni Collieries Limited in Telangana has implemented longwall mining projects, indicating a growing trend.

Challenges and Considerations:

- Geological and Structural Issues:
  - o Unpredictable geological formations (fault zones, unstable roofs) leading to roof cavities and safety risks.
  - o High horizontal stress affecting roof, floor, and rib stability.

- Operational Challenges:
  - o Extensive equipment maintenance to prevent failures and safety hazards.
  - o Accurate longwall face alignment to avoid machinery damage and inefficiencies.

- Environmental Impact:
  - o Water management to prevent hazardous conditions like mud pools.
  - o Significant surface subsidence, potentially affecting ecosystems and infrastructure.

- Safety Concerns:
  - o Inherent dangers from heavy machinery and potential roof collapses.
  - o Dust generation posing respiratory hazards.

- Economic Factors:
  - o High initial capital investment for specialized equipment and infrastructure.
- Technological and Labor Adaptations:
  - o Balancing automation with workforce needs to avoid job displacement.

Technological Innovations and Future Directions:

- Advancements in cavity-filling materials (phenolic foams) to stabilize roof conditions.

- Ongoing research into automation and robotics to enhance safety and reduce manual labour in hazardous environments.

- Emphasis on sustainable mining practices, carbon management, and minimized environmental impact.

- Integration of digital technologies to improve efficiency and safety.

- The use of MPT (Mass Production Technology) in underground mining, with longwall technology being a prime candidate, is being pushed in India.

- Advancements in carbon capture and storage, and the development of alternative energy sources, will influence the future of longwall mining.

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