COAL INTERNATIONAL

Volume 272 · Number 6 November-December 2024

Tradelink Publications Ltd

Publishing, Printing & Website Services for the Mining Industry

COAL INTERNATIONAL

MINING & QUARRY WORLD

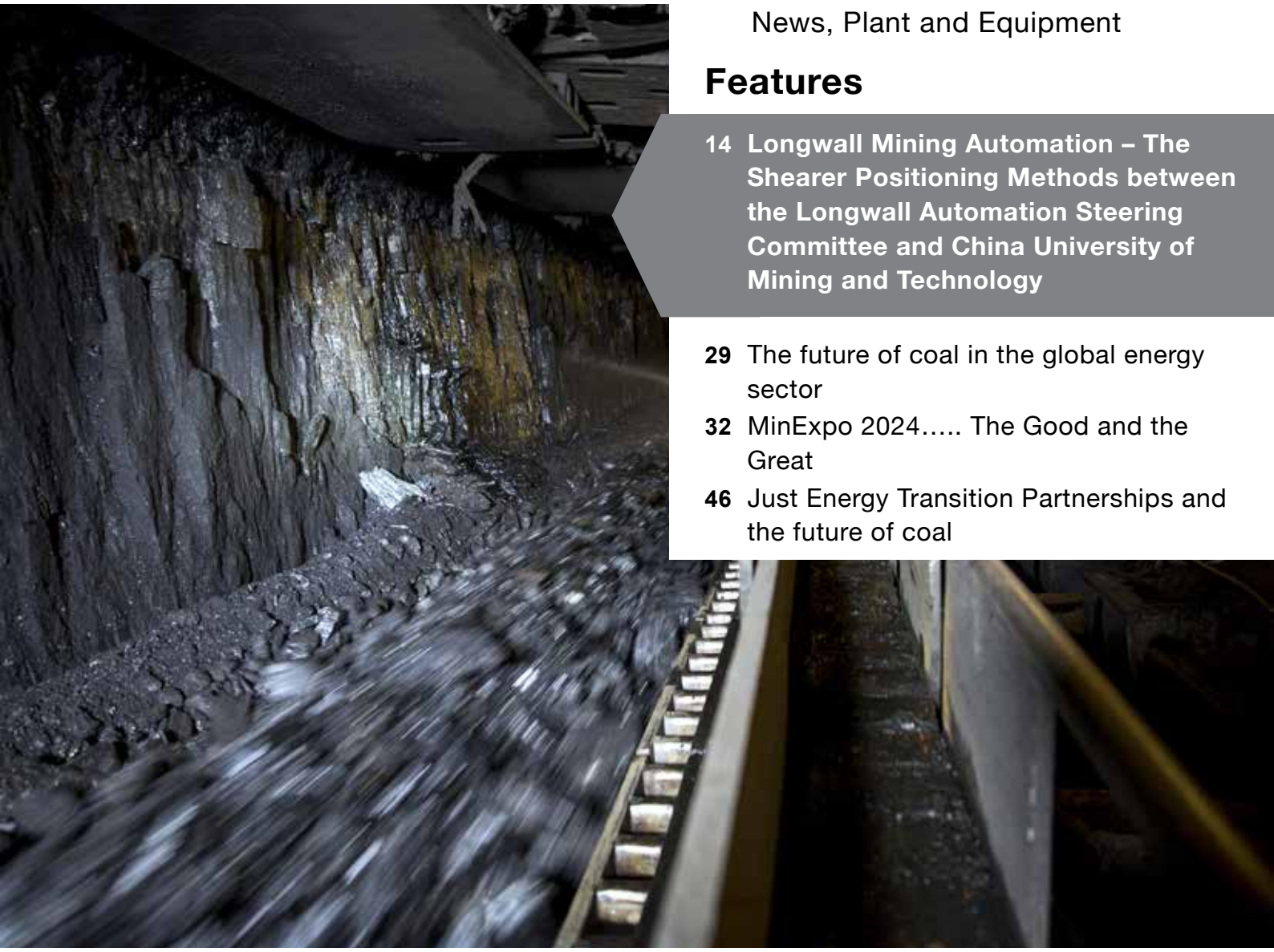
All issues of Mining & Quarry World & Coal International are free to download

2025 Editorial Programme

To receive your copy of our 2025 media pack please contact
gordon.barratt@tradelinkpub.com
+44 (0)1777871007 | +44 (0)1909474258
alternatively download from our web site www.mqworld.com

Volume 272 • Number 6 • November-December 2024

CONTENTS



News, Plant and Equipment

Features

Managing Director and Publisher: Trevor Barratt

International Sales:

Gordon Barratt +44 1909 474258 gordon.barratt@tradelinkpub.com

Graphic Designer: Sarah Beale sarah@g-s-g.co.uk

Published by: Tradelink Publications Ltd.

16 Boscombe Road, Gateford, Worksop, Nottinghamshire S81 7SB

Tel: +44 (0)1777 871007

Fax: +44 (0)1777 872271

E-mail: admin@mqworld.com

Web: www.mqworld.com

Anglo American to sell stake in Jellinbah

Anglo American has reached an agreement to sell its 33.3% minority interest in Jellinbah Group to Zashvin for $1.6 bn.

The transaction will see Zashvin, an existing 33.3% shareholder in Jellinbah, increase its stake in the joint venture (JV) that owns a 70% interest in the Jellinbah East and Lake Vermont steelmaking coal mines in Australia.

The sale, subject to regulatory approvals, is anticipated to be completed by the second quarter of 2025.

"We are delighted to have agreed terms with our JV partner Zashvin for the sale of our minority interest in Jellinbah," Anglo American chief executive Duncan Wanbland said.

"The cash proceeds of $1.6 bn reflect the exceptional quality of the Jellinbah business.

"Our process to sell the rest of our steelmaking coal business is now at an advanced stage and we are on track to agree terms in the coming months."

Zashvin's James Xu thanked Anglo American for its role in Jellinbah's development and highlighted confidence in Queensland's coal sector.

"Jellinbah's success has been driven by robust partnerships," Xu said. "We're appreciative of Anglo American's significant role in this journey and we value its dedication to making this transaction smooth and efficient.

"As a family that's been with Jellinbah since its inception, our increased investment not only reflects our confidence in Queensland's coal industry but also our commitment to supporting the central Queensland community."

Anglo American is making a strategic shift toward higher-margin assets.

"We are making excellent progress with our simplification of Anglo American to create an exciting and differentiated investment proposition focused on our world-class copper, premium iron ore and crop nutrients assets – all future-enabling products," Wanbland said.

"This highly cash generative and much higher margin portfolio will offer greater resilience through cycles and the benefit of significant high quality and well sequenced growth options, including a clear path to increase annual copper production to more than one million tonnes by the early 2030s."

In 2023, Anglo American's 33.3% interest in Jellinbah contributed $US779 m to revenue and $US373 m in underlying earnings before interest, taxes, depreciation and amortisation (EBITDA).

The first half of 2024 saw revenue contributions of $US354 m and $US153 m to underlying EBITDA.

UzXCMG celebrates 10 years and rolls out 3000th machine amid expansions

Marking its 10th anniversary, the UzXCMG joint venture, subsidiaries of XCMG Machinery, has successfully manufactured its 3000th piece of equipment and announced significant expansions including a new customs warehouse to boost logistics efficiency. The milestone was celebrated on October 21st with multiple agreements signed to enhance local industry and talent development.

Since its establishment in 2014 as XCMG's first manufacturing base in Central Asia, UzXCMG has rooted itself deeply into the local market. Over the past decade, it has delivered thousands of machines widely used in mining, municipal engineering, and agricultural irrigation projects across Uzbekistan. This contribution has significantly propelled economic growth within the region.

The anniversary event was highlighted by a series of celebratory activities including the signing of a major contract for one hundred wheel excavators. These machines are set to support various large-scale projects in urban construction and mining sectors locally. Additionally, UzXCMG inaugurated its customs warehouse, which is expected to greatly enhance clearance and logistics operations facilitating quicker customer responses.

In an effort to foster local talent development, Xuzhou Construction Machinery Technician College along with UzXCMG signed cooperation agreements with representatives from Khwarezm regional government. These agreements aim at establishing the XCMG Modern Construction Equipment Industrial Academy, which will integrate educational resources from government, enterprises, and schools creating a leading example for industry education while training skilled local personnel.

Yang Dongsheng, chairman of XCMG Machinery, expressed confidence in deepening cooperation within Uzbekistan under the Company's localized strategy "In Uzbekistan, For Uzbekistan." He emphasized this approach as foundational for transforming UzXCMG into Central Asia's production hub over the next decade, injecting new vitality into regional development.

Murodjon Achilov Azamatovich, First Deputy Governor of Khorezm region praised UzXCMG's contributions saying, "Not only does UzXCMG provide us with advanced engineering machinery, but also plays a crucial role in our economic growth through job creation and skill training programs."

With these developments, UzXCMG not only commemorates ten years of successful operations, but also sets a robust foundation for future growth ensuring continued support towards Uzbekistan's developmental goals.

Coal a winner for Glencore

Glencore has maintained its 2024 production guidance during the September quarter while delivering an increase in steelmaking coal volumes.

The company's steelmaking coal volumes increased to 11.1 million tonnes (Mt), a substantial 113% increase from the same period in 2023.

The uptake was credited by Glencore chief executive officer Gary Nagle to the company's 77% stake in Elk Valley Resources (EVR), Teck Resources' steelmaking coal subsidiary, which it acquired in July. During the September quarter, 5.7Mt of steelmaking coal was produced by Glencore.

Other quarterly highlights for Glencore include its copper production sequentially increase by nine% to 242,600 tonnes (t), which reflected the progressive recovery at the Antapaccay mine in Peru following a geotechnical event in the first half of the year.

The copper increase was also caused by higher feed grades at the Collahuasi mine in northern Chile and improved production levels at Glencore's operations in the Democratic Republic of Congo: Mutanda Mining – which Glencore fully owns – and Kamoto Copper Company, which Glencore owns a 75% stake in.

Glencore also delivered a seven% zinc production increase during the quarter, with the amount rising to 226,400t thanks to the ramp up at the Zhairem operation, which Glencore owns almost 70% of.

The company's ferrochrome production of 894,000t was broadly in line with the comparable 2023 period.

While Glencore saw production decreases in cobalt, nickel and silver for the quarter, Nagle said the company's 2024 guidance remains unchanged.

"(Based on marketing's) performance year to date, we continue to expect full year marketing adjusted EBIT (earnings before interest and taxes) in the $3-$3.5 billion range, being around the top end of our long-term $2.2-3.2 billion per annum guidance range," he said.

Earnings up for New Hope

New Hope Group's underlying earnings before interest, taxes, depreciation and amortisation (EBITDA) was up 40.8% for the quarter.

EBITDA was reported at $304.6 million, which New Hope attributed to stronger production and higher realised pricing.

Group coal sales sat at 2.8 million tonnes, an 8.1% increase compared to the previous quarter. This was driven primarily by a 21.1% increase in coal sales at the Bengalla mine in New South Wales.

Bengalla recorded a strong operational performance in the first quarter of the 2024–25 financial year (FY25) due to the easing logistical disruptions and the unwinding of in-pit inventories and product coal stocks.

New Hope was able to run the upgraded processing plant closer to expectations, while the construction phase of growth project infrastructure continued with the opening of a new public car park, the commencement of warehouse upgrades, and additional progress on the new operations hub.

The company also received approval from the NSW Resources Regulator to carry out accessible prospecting operations at Bengalla, covering an area of 556 hectares.

"The exploration drilling program continued during the quarter, with two drill rigs completing 14 holes for a total of 4717m," New Hope said. "There were six fully cored and two partially cored holes, drilled for coal quality and fugitive greenhouse gas emissions assessment.

"A further six holes were subject to chipped rotary mud drilling, primarily for structural characterisation. All holes were geophysically logged and a total of 120 fugitive gas emission samples were taken, along with 492 coal quality samples and 161 geotechnical samples."

Completion of the program is planned for the third quarter of FY25.

China Ramps Up Coal Power as Energy Demand Surges

Although the share of coal in China's electricity generation has been declining in recent years with the renewables boom, Chinese coal power generation and demand remains strong.

Coal still accounts for about 60% of China's power generation, despite a surge in hydropower earlier this year after abundant rainfall, which reduced the share of coal in the country's energy mix during the summer.

But hydropower saw a sharp decline in September, which boosted the use of thermal coal for power generation amid surging power demand in the world's second-largest economy.

China's thermal power generation, which is overwhelmingly coal-fired, jumped by 8.9% last month, per official data cited by Reuters's columnist Clyde Russell.

Total power generation rose by 6% in September from a year earlier as electricity demand has started to outpace China's economic growth in recent years.

Power demand jumped by 8.5% in September from the same month last year, while year to date, Chinese power consumption also rose by a similar percentage, 7.9% year-over-year, per the data quoted by Reuters's Russell.

The surge in Chinese power consumption has led to high coal demand, too, as the power sector continues to rely on thermal generation for a stable supply of electricity amid soaring demand.

This demand is not only the result of a growing economy. China's economy has expanded by less than 5% so far this year, and analysts fear the country could miss its own 2024 growth target of "about 5%."

Related: Argentina's Shale Boom Goes Global

The surge in power demand has also been attributed to the increased use of household appliances amid rising numbers of middle-class residents, as well as the surge in power use for data centers and electric vehicle charging.

Chinese electricity consumption in the data services industry and for charging and battery services soared in the first half of 2024, driven by technology and electric vehicles, data from the China Electricity Council has shown.

Power consumption in data centers, big data, and cloud computing jumped by 33% between January and June compared to the same period in 2023.

In addition, China's EV sales have already topped conventional car registrations for three consecutive months. EV and plug-in hybrid sales surged by 50.9% in September from a year earlier, grabbing a 52.8% share of total sales, the latest Chinese data showed earlier this month.

Electricity consumption per capita in China already exceeded that of the European Union at the end of 2022 and is set to rise further, the International Energy Agency (IEA) said in its Electricity Mid-Year Update report in July.

"The rapidly expanding production of solar PV modules and electric vehicles, and the processing of related materials, will support ongoing electricity demand growth in China while the structure of its economy evolves," the IEA noted.

Despite continued growth in coal-fired power generation, China reached a momentous milestone in clean energy in the first half of the year, as rising hydropower, solar, and wind output pushed down the share of coal in power generation to below 60% for the first time ever.

Solar and wind power contributed to this achievement, but it was mostly the result of a rebound in hydropower generation, which squeezed coal in the late spring and summer, thanks to heavy rainfalls.

Come September, however, hydropower generation crashed by 14.6% from a year earlier. And rising coal power generation filled in the gap.

Coal-fired generation will be a pillar of China's electricity generation system for many years to come, as the country's electricity demand growth is set to continue outpacing economic growth in the coming years and as electrification is booming with the energy transition and expansion of data centers

PR to construct rail line connecting Thar mines to Port Qasim

Pakistan Railways is planning to construct a 105 kilo-metre railway line that will intend to link Thar Coal mines with the Port Qasim.

"The department has already awarded the contract which will schedule to complete by October 2025," an official in the Ministry of Railways told APP.

He said, "The aim for bolstering the nation's bulk transportation capabilities, aligns with broader economic growth objectives and facilitate coal transportation across the country."

The official said, "The project is a joint venture which is financed by both the Sindh and federal governments."

"The new rail link from Islamkot to Chhor will facilitate in coal transportation across the country, supporting key industries like cement and textiles by providing a more cost-effective fuel alternative," he added.

He said, "The construction will include a 24.58-kilometer loop-line and an 18-kilometer double line track extending from Bin Qasim railway station to Port Qasim, with additional 4.20 kilometers of loop-lines designed to handle significant freight volumes."

After the completion of the project, he said, "The rail network is expected to have the capacity to transport 10 million tons of coal annually, shifting the country's power generation reliance from imported to domestic coal sources."

He said, "The project will see the establishment of seven new railway stations along the route, with two major stations at Thar coal mines and new Chhor station and five intermediate stations to facilitate efficient coal transport."

Bangladesh seeks to review major energy projects

A review committee formed by Bangladesh's interim government recently recommended engaging an investigation agency to examine power agreements signed by deposed prime minister Sheikh Hasina's regime with different business groups, including one with India's Adani Group.

The National Review Committee on Ministry of Power, Energy and Mineral Resources has recommended the appointment of a reputed legal and investigation agency to review the major power production agreements signed during the autocratic regime of Sheikh Hasina from 2009 to 2024, an official statement said.

The statement, issued by Chief Adviser Muhammad Yunus's office, said the committee was currently reviewing seven major energy and power projects, including the Adani (Godda) BIFPCL 1234.4 MW coal-fired plant, a wholly-owned subsidiary of Adani Power Limited.

The six other agreements include one with a Chinese company that built a 1320 MW coal-fired power plant, while the rest are with Bangladeshi business groups said to be close to the past regime.

According to the statement, the committee gathered enormous proof warranting the agreements be scrapped or reconsidered in line with international arbitration laws and procedures. It said the committee needed additional time to further analyse other solicited and unsolicited contracts.

In doing so, we recommend immediate appointment of one or more top-level international legal and investigation agency or agencies to assist the committee, the statement said quoting a letter of the committee, headed by retired High Court judge Moyeenul Islam Chowdhury.

India's External Affairs Ministry had earlier said that cooperation in the power and energy sector has become one of the crucial pillars of India-Bangladesh relations.

The Adani Group, however, recently sent a letter to the Bangladesh government over its unpaid USD 800 million power supply bill while Bangladesh's state-run Power Development Board said they had already paid USD 150 million despite its dollar crisis and was expecting to pay the full amount.

Adani's Godda thermal plant was set up exclusively to supply power to Bangladesh but India recently changed a law allowing the Indian company to sell the Godda power in the domestic market sparking speculation if Bangladesh would get dedicated power supply from the plant.

The interim government had earlier formed a committee to examine contracts made under the Quick Enhancement of Electricity and Energy Supply (Special Provisions) Act, 2010 (Amended 2021).

The committee was tasked to investigate any allegations of corruption related to the country's electricity and energy production and supply agencies.

The UK coal-fired power station that became a giant battery

With the closure of the last coal-fired power station in the UK, it raises questions about how old fossil fuel infrastructure can be repurposed. One option is to use them to store energy from renewables.

It's an unassuming place for a major era of British history to come to an end. Surrounded by farmland drenched by recent rains and trees with leaves starting to turn ahead of the autumn – all within earshot of the thundering traffic from the M1 motorway – the UK's last coal-fired power station is shutting down for good. As of 30 September 2024 the turbines at the Ratcliffe-on-Soar power plant in Nottinghamshire will fall silent while smoke and steam will cease to belch from the chimney and cooling towers that dominate this part of the landscape.

The power station, which has been operating since 1967, is to undergo a two-year decommissioning and demolition process.

It's a symbolic moment, a marker along the UK's journey to decarbonisation and net-zero. For centuries, coal was the main source of energy in the UK. It was the life-blood of the industrial revolution – providing the fuel for steam engines and then generating much of the country's electricity. By the 1960s, nearly 90% of the UK's electricity relied upon coal.

Now, for the first time, the UK will not use any coal to generate electricity.

It's not clear what the Ratcliffe-on-Soar site will become. There have been suggestions it could house a prototype fusion reactor or some other green industry. Regardless, as fossil fuel power plants are shuttered in many parts of the world, the question of what to do with them will keep coming up.

One promising option is to turn old fossil power plants into battery storage sites.

The intermittency problem

Renewable energy sources like wind and solar are the mainstay of the net-zero transition. They don't emit greenhouse gases, so the more they replace fossil fuels like coal and gas the closer we come to net-zero emissions.

The share of energy coming from renewables is rising steadily. According to a report by the International Energy Agency published in January 2024, renewables will generate 33.5% of global electricity this year and could account for 41.6% by 2028.

However, using renewables comes with challenges for power grids. Coal and gas plants can be turned on and off at will, so they can supply more energy when it is needed: they are "dispatchable", in the jargon of the field. By contrast, renewable sources are intermittent and less controllable: the Sun doesn't shine at night and the wind doesn't always blow (and sometimes can blow too much).

"With renewables, we have less dispatchable power," says Grazia Todeschini, an electrical engineer at King's College London in the UK.

To some extent, the intermittency problem can be managed by having a diverse selection of renewable sources: that way, if one doesn't generate enough, another can pick up the slack. Nuclear power, which is zero-carbon, also offers a steady supply.

Alongside this, though, countries are investing heavily in energy storage. When lots of electricity is generated but isn't needed, it can be stored – then when there is a shortage it can be released. "The main point is to be able to match generation and demand," says Todeschini.

For many decades, the most important form of energy storage was pumped hydropower. Excess electricity was used to pump water uphill, so that it could be released to drive turbines and generate electricity when needed. However, this won't be enough for the renewable era, and hydropower has its own emission problems too. "That capacity pretty much is saturated everywhere, in Europe at least," says Todeschini. "There is no space to build any more."

That's why many countries are turning instead to battery energy storage systems (BESS). A BESS site is simply an array of batteries: big ones, about the size of shipping containers. Excess electricity from renewable sources can be dumped into the batteries, ready to be discharged when demand is high.

"In the last 20 years, this technology has improved a lot," says Todeschini. "The control is more precise, and also the cost has decreased."

All of which explains why one of the UK's defunct coal plants is being turned into a BESS site.

Ferrybridge

Near Ferrybridge in West Yorkshire sit the remains of a trio of coal-fired power plants. Between them they operated for almost a century, the first one turning on in 1927 and the last being decommissioned in 2016. The third station, Ferrybridge C, passed into the ownership of energy company SSE in 2004, which ran it until the site's closure and demolition.

Now SSE is building a BESS on the site of Ferrybridge C. It will have a capacity of 150 megawatts, which SSE estimates will be enough to power 250,000 homes. Construction began in August 2023, and in

One of the UK's defunct coal plants in Ferrybridge, West Yorkshire, is being turned into a battery energy storage system (Credit: Getty Images)

June 2024 the first batteries arrived. The following month, the last of the 136 battery units were installed.

"We're now at the point all the kit's on site," says Heather Donald of SSE Renewables, where she is director of onshore wind, solar and battery for Great Britain and Ireland. "We're just about to go into the commissioning phase and we're hoping to switch on early next year."

Building an array of batteries on the site of an old coal-fired power station has multiple advantages, says Donald. "First and foremost, there's a grid connection there," she says. That means linking the BESS to the grid is as straightforward as it can be. "Access to grid connections and grid capacity's at such a premium now."

The site also proved to have a lot of useful materials and infrastructure. "We've been able to use some of the existing concrete foundations, we've been able to repurpose some of the concrete on site," says Donald. This meant the company did not need to import many materials, apart from the batteries themselves.

"It's a great reuse of a site like this," says Donald.

More of this sort of thing

If the UK is to achieve its decarbonisation targets, it will need a lot more BESS projects like Ferrybridge.

Some indication of quite how many more can be gleaned from the latest Future Energy Scenarios report, released in July 2024 by National Grid. The report finds the UK had 4.7 gigawatts (GWs) of battery storage in 2023. That's a lot, but the UK government has set a legally binding target of net-zero emissions by 2050. Depending on quite how this is achieved, the country will need storage of between 29 gigawatts and 36 gigawatts by 2050. Even the lower figure is only possible if the UK stores a lot of its energy in the form of hydrogen. Currently, most hydrogen comes from fossil fuel sources, so a switch to greener alternatives is needed. If green hydrogen does not take off, the country will need more BESS to compensate.

In short, the UK's BESS capacity needs to increase by a factor of at least six, and possibly closer to eight, in the next quarter-century.

Many more BESS sites are in the pipeline for the UK. In June 2024, plans were approved for a BESS facility in a field near the hamlet of Wineham in West Sussex. Another near Sunderland was recommended by city planners in August. Weeks later, a similar facility was approved for agricultural land in Cumbria.

Given the massive increase in battery capacity needed, disused power stations like Ferrybridge C are a tempting option. "To be able to use former energy sites for new carbon-free energy is definitely something we're looking to do more of," says Donald.

Indeed, SSE is already building a second BESS on another coal-fired power station site. Fiddler's Ferry in Warrington, Cheshire, was shut down in 2020, and in December 2023 the company announced it would turn it into a 150-megawatt BESS. Construction began in the spring of 2024.

"I agree it makes sense to use a site where there is already some of this infrastructure," says Todeschini.

That said, not all ex-fossil-fuel power stations will be suitable for BESS. "It really depends a lot on the location," says Todeschini. For instance, a site that's a long way from residential neighbourhoods might not be suitable. Instead, such sites could be repurposed as wind farms or other forms of generation. Todeschini also suggests charging sites for fleets of electric vehicles.

"I'm an advocate for this kind of mixed approach, in general, for the energy transition," says Todeschini. "My approach is to really consider all options."

Nevertheless, many former fossil fuel power plants around the world are being repurposed for batteries.

More like this:

- How flooded coal mines could heat homes
- The old oil tankers being rehabilitated
- A new use for abandoned oil rigs

In the Lusatia region of Germany, there is an intricate system of coal mines and thermal power plants operated by the energy company LEAG. In 2023, the company – which specialises in the dirtiest form of coal, lignite – announced a plan to transform the entire complex into a "green energy hub". This will include wind and solar, hydrogen and batteries, and is intended to be completed by 2040. An early step will be to convert the Boxberg coal plant into a BESS facility, to be operational by 2027. In June 2024, LEAG secured €58 million of European Union funding to support the project.

On the other side of the world, the former Liddell Power Station in New South Wales, Australia, is becoming the Liddell Battery. The site's owner AGL Energy announced the project in December 2023 and construction began in June 2024. The 500-megawatt batteries should come online in December 2025.

Finally, Nevada is home to a project that is already storing and supplying electricity. The coal-fired Reid Gardner Power Station, 50 miles (80km) north-east of Las Vegas, was demolished in 2020. A company called Energy Vault has since replaced it with the Reid Gardner Battery Energy Storage System, which has a capacity of 220 megawatts. The site came online in late April 2024.

The more projects like these come online, the better they will become, argues Donald. "It's obviously an emerging technology," she says. Donald expects BESS to become more efficient and to be able to discharge electricity for longer periods – helping ensure a secure electricity supply after all the fossil fuel plants have been turned off for good.

The BESS at Ferrybridge C will have a capacity of 150 megawatts - enough to power 250,000 homes (Credit: Getty Images)

S.Africa offers a lesson on how not to shut down a coal plant

The cold corridors of South Africa's once-mighty Komati coal-fired power plant have been quiet since its shutdown in 2022 in what was trumpeted as a pioneering project in the world's transition to green energy.

Two years later, plans to repurpose the country's oldest coal power plant have amounted to little in a process that offers caution and lessons for countries intending to reduce their reliance on fossil fuels and switch to renewables. Jobs have been lost and construction for wind and solar energy generation has yet to start, with only a few small green projects under way. "We cannot construct anything. We cannot remove anything from the site," acting general manager Theven Pillay told AFP at the 63-year-old plant embedded in the coal belt in Mpumalanga province, where the air hangs thick with smog. Poor planning and delays in paperwork to authorise the full decommissioning of the plant have been the main culprits for the standstill, he said. "We should have done things earlier. So we would consider it is not a success.

Before it turned off the switches in October 2022, the plant fed 121 megawatts into South Africa's chronically undersupplied and erratic electricity grid.

The transition plan – which won $497 million in funding from the World Bank – envisions the generation of 150 megawatts via solar and 70 megawatts from wind, with capacity for 150 megawatts of battery storage. Workers are to be reskilled and the plant's infrastructure, including its massive cooling towers, repurposed. But much of this is still a long way off.

"They effectively just shut down the coal plant and left the people to deal with the outcomes," said deputy energy and electricity minister Samantha Graham.

Disgruntled Komati is the first coal plant scheduled for decommissioning, with five of the remaining 14 ones meant to follow by 2030.

Coal provides 80% of South Africa's power and the country is among the world's top 12 largest greenhouse gas emitters. Coal is also a bedrock of its economy, employing around 90,000 people.

South Africa was the first country in the world to form a Just Energy Transition Partnership (JETP) with international funders to move off dirty power generation, already receiving $13.6 billion in total in grants and loans, Neil Cole of the JETP presidential committee told AFP.

Komati is the first coal plant scheduled for decommissioning, with five of the remaining 14 ones meant to follow by 2030. It had directly employed 393 people, the state energy firm Eskom that owns the plant told AFP. Only 162 remain on site as others volunteered for transfer or accepted payouts. The plant had been the main provider of employment in the small town, where the quiet streets are pitted with chunks of coal.

Today, several houses are vacant as workers from other provinces headed home after losing their jobs. "Our jobs ending traumatised us a lot as a community," said Sizwe Shandu, 35, who had been contracted as a boilermaker at the plant since 2008. The shutdown had been unexpected and left his family scrambling to make ends meet, he said.

With South Africa's unemployment rate topping 32%, Shandu now relies on government social grants to buy food and electricity.

Pillay admitted that many people in the town of Komati had a "disgruntled

view" of the transition. One of the mistakes was that coal jobs were closed before new jobs were created, he said. People from the town did not always have the skills required for the emerging jobs. Eskom has said it plans to eventually create 363 permanent jobs and 2,733 temporary jobs at Komati.

One of the green projects under way combines raising fish alongside vegetable patches supported by solar panels.

One of the green projects under way combines raising fish alongside vegetable patches supported by solar panels. Seven people, from a planned 21, have been trained to work on the aquaponics scheme, including Bheki Nkabinde, 37. "Eskom has helped me big time in terms of getting this opportunity because now I've got an income, I can be able to support my family," he told AFP, as he walked among his spinach, tomatoes, parsley and spring onions. The facility is also turning invasive plants into pellets that are an alternative fuel to coal and assembling mobile micro power grids fixed to containers. A coal milling workshop has been turned into a welding training room.

Mistakes and lessons

The missteps at Komati are lessons for other coal-fired power plants marked for shutdown, Pillay said. For example, some now plan to start up green energy projects parallel to the phasing out of fumes. But the country is "not going to be pushed into making a decision around how quickly or how slowly we do the Just Energy Transition based on international expectations", said Graham. South Africa has 7% renewable energy in its mix, up from 1% a decade ago, she said. And it will continue mining and exporting coal, with Eskom estimating that there are almost 200 years of supply still in the ground.

Workers are to be reskilled and the plant's infrastructure, including its massive cooling towers, repurposed. Photo: PAUL BOTES / AFP Source: AFP

The goal is to have a "good energy mix that's sustainable and stable", Graham said. Since South Africa's JETP was announced, Indonesia, Vietnam and Senegal have struck similar deals, but there has been little progress towards actually closing coal plants under the mechanism.

Among the criticisms is that it offers largely market-rate lending terms, raising the threat of debt repayment problems for recipients.

Xinjiang launches lab program focusing on sci-tech development of coal resources

Experts from China's leading academic institution launched a laboratory program recently in the Xinjiang Uygur Autonomous Region to address scientific and technological challenges in the local coal mining industry.

The lab, named after Xinjiang's landmark Tianshan Mountains, is led by the Chinese Academy of Engineering. It will leverage Xinjiang's abundant coal resources and geographical advantages to focus on such key areas as safe and intelligent coal mining, clean and efficient processing and utilization, water resource protection and ecological restoration in coal mining areas, the integration of coal with renewable energy, and the exploration and development of coalbed methane resources.

Xinjiang has 2.19 trillion tonnes of coal resources, accounting for approximately 40% of the country's total. However, compared to other coal-rich provinces, the remote region in northwest China has lagged behind in terms of exploration, efficient utilization and the coal-to-green transition.

Academician Peng Suping, who leads the expert team, said that the goal is to establish a world-class sci-tech platform that can provide prompt solutions to technical challenges in local industrial chains and promote large-scale, safe, intelligent, efficient and environmentally friendly coal resource development.

Peng is an expert in the fields of mine engineering geology and geophysical prospecting. He also leads the State Key Laboratory of Coal Resources and Safe Mining, which is administered by the Ministry of Science and Technology.

The new lab is located in the regional capital of Urumqi and has received support from three local colleges and universities. Numerous large domestic enterprises have been eager to participate in its establishment.

In 2023, Xinjiang's raw coal output reached 457 million tonnes, an increase of 10.7% compared to the previous year. The increased output secured the top position among major coal-producing provinces. Its coal export volume surpassed 100 million tonnes for the first time last year.

Ukraine's steel output will halve if Pokrovsk falls

Russian troops are approaching a critical metallurgical (or coking) coal mine near Pokrovsk in Donetsk Oblast. The loss of this mine could result in "serious damage to Ukraine's economy

The coal mine is located to the west of central Pokrovsk. Kalenkov explained that the threat to the Pokrovsk mine, Ukraine's only source of metallurgical coal, could lead to a reduction in steel production.

"We could make up to 7.5 m metric tons of steel by the end of the year and, for next year, we saw an increase in production to over 10 m," said Kalenkov.

"But if we lose Pokrovsk, then ... we will fall to 2-3 m tons."

Anatoliy Starovoit, head of the Ukrkoks association, told reporters that Ukraine produced about 3.5 m tons of coke in 2023, relying on Pokrovsk as the only source of metallurgical coal.

"We don't know where to get coal if Pokrovsk is seized," he told Reuters.

"It is difficult to bring it in by importing; today it is not so easy to bring it in by sea."

A source in the metallurgical industry told journalists that producers hope to find alternative sources of coking coal in other regions of Ukraine if Pokrovsk is occupied. However, imports would be necessary in the meantime, increasing production costs and making Ukrainian steel less competitive.

Russian Railways' tariff hike to raise thermal coal export prices

State-owned Russian Railways' (RZD) 13.8% freight tariff hike, effective Dec. 1, is likely to squeeze thermal coal exporters' profit margins, boost offer prices at the ports and increase logistics costs for buyers willing to shoulder the higher price, market sources said recently.

Russia has increased rail freight tariffs as its coal exporters grapple with lower demand in several major markets amid sanctions on several Russian companies.

"Russian coal miners are already making a loss in 2024, and higher tariffs will add to costs and reduce the price competitiveness of Russian thermal coal, giving room for coal from Colombia, South Africa and the US to gain market share in the seaborne market," said Pat Se Khoo, senior analyst with S&P Global Commodity Insights.

Russian thermal coal exports reached 110 million mt in 2024 as of Nov. 13 and compare with 133 million mt in full-year 2023, showed S&P Global Commodities at Sea data.

In 2024, Russia supplied 23.23 million mt to the Japan-South Korea-Taiwan market, 43.9 million mt to China and 8.2 million mt to India.

The exports rose 12.1% year on year to 148 million mt in 2022.

Market sources expect exports to slow this year due to a reduction in price competitiveness.

"The new hike in rail freight will result in higher selling prices for Russian coal," said a UAE-based analyst dealing in Russian coal. "Buyers will either need to accept the higher prices, or they will seek cheaper alternatives. However … there is a shortage of spot high calorific-value coal, so buyers will end up paying a premium anyway."

High CV liquidity declines

Higher transportation costs have eroded Russian suppliers' profit margins, tightening cargo availability on the east coasts and weighing on high CV 6,000 kcal/kg NAR grade liquidity.

A Singapore-based trader said that when RZD raised rail tariffs by 10.75% in 2023, some new coal projects were shelved. The outcome may be similar this year, and Russian thermal coal exports could decline further.

The tariff increase could also impact export volumes to price-sensitive buyers such as India and China, as coal outflows rely on rail transportation.

"In the last nine months, exports have been in the 50:50 ratio between China and other markets," a Russian trader said. "However, as we go forward, this ratio could decrease in favor of premium markets, including South Korea, Japan, and Malaysia, as less material will be delivered to the Far East."

Russian 6,000 kcal/kg NAR price discussions to South Korea for December-loading Panamax cargoes were in a wide range from $116/mt CFR to $125/mt CFR over Oct. 6-Nov. 8. Indicative prices to China were heard at $106/mt CFR and $107/mt CFR for Russian 5,500 kcal/kg NAR from the east coast during the period.

Buying indications from India for Russian 6,000 NAR were heard at around $110/mt CFR from the east coast during the period, with only a few offers for India at prices not less than $118/mt CFR, market sources said.

The Platts-assessed price of FOB Russia Pacific 6,000 kcal/kg NAR averaged $94.15/mt FOB over January-October, down from $115.70/mt FOB a year earlier. Platts, part of Commodity Insights, last assessed the grade at $104/mt on Nov. 8.

China Baoli Partners with Van Pacific for Mongolian Venture

China Baoli Technologies Holdings Ltd. has announced a strategic collaboration with Van Pacific Resource Ltd. to develop a coal mining operation in Mongolia, aiming to increase production to 5 million tons annually. The partnership will also explore expanding into cryptocurrency mining and data centers using cost-effective power solutions. This venture aligns with Mongolia's growing prominence as a major coal exporter, particularly to China.

Climate skeptics urge Trump to boost coal

Activists who dispute the severity of climate change enjoyed cachet in Donald Trump's first administration and salivated over the prospect of his return to the White House. Now that he's won, they've delivered a wish list to his transition team.

At the top of their agenda: Terminating federal science advisory boards, reviewing air-quality regulations issued by the Environmental Protection Agency and repealing President Joe Biden's "anti-coal regulatory actions," as well as promoting coal as "a preferred means of electricity."

Groups behind the memo include the Illinois-based Heartland Institute, an Illinois-based think tank that has argued global warming is beneficial; the Energy & Environment Legal Institute, a Virginia-based organisation; and the Committee for a Constructive Tomorrow, which runs a website that promotes climate change skepticism. One of Energy & Environment's leaders advised Trump's EPA transition team after his first election win, and Heartland's president has touted its ties with the incoming administration.

The Trump transition team didn't immediately respond to a request for comment.

Scientists are near unanimous that the atmosphere has warmed more than 1oC since the Industrial Revolution, due to human activity and especially burning fossil fuels. They agree that emissions of carbon dioxide and other greenhouse gases must be reduced sharply to maintain a habitable planet. The US is the world's second-biggest emitter of greenhouse gases.

The skeptics' to-do list, or parts of it, could find a welcome home in the incoming administration. The president-elect has mocked climate change as a "hoax" and a "scam" and employed a number of climate science critics in prominent roles during his first term.

"This is a tremendous opportunity," said James Taylor, the president of the Heartland Institute. "Donald Trump has demonstrated during his first four years in office that he will not be misled by the climate crisis myth."

On some points, the groups' agenda already dovetails with Trump's stated aims. Trump is a vocal critic of wind energy and has said he will target the industry; the activists want him to "delist" areas designated for future offshore wind projects. They also want the next administration to prevent the grid from becoming reliant on "variable" wind and solar as a matter of national security. And if Trump pulls the US back out of the 2015 Paris climate accord, as he's vowed to, they want him to take that further by formally sending it to the Senate for a vote – a move that could prevent a future Democratic president from rejoining the agreement.

The groups urge Trump to crack down on science in the EPA in particular. They want a repeal of the agency's 2009 "endangerment finding," which found that the buildup of greenhouse gases in the atmosphere endangers public health, and which underpins many US environmental rules. They also hope to reinstate the "secret science" rule from Trump's first term. This limited the use of research to craft regulations unless the authors disclosed the data they used. Critics said the rule excluded important research such as public-health studies based on anonymized patient data.

Environmentalists say adopting the agenda would reverse US progress in cutting emissions, after the outgoing Biden administration made tackling climate change a priority. The world has almost breached the 1.5oC warming threshold that countries agreed on in the Paris accord. Earth is currently on track for 3.1oC of warming, the United Nations recently said.

The groups' memo "clearly reads like an oil and gas industry wish list," said Kalee Kreider, who formerly advised Al Gore on environmental issues and is now president of public affairs firm Ridgely Walsh. But, she added, it appears to underestimate the shift to clean energy that has already taken place, including in red-leaning parts of the country.

"It looks to me there is an overreach – and almost even a misread – from where we were in 2016 to where we are today," she said.

Longwall Mining Automation – The Shearer Positioning Methods between the Longwall Automation Steering Committee and China University of Mining and Technology

The shearer positioning method is of great significance to the automation of longwall mining. The research teams in the Longwall Automation Steering Committee (LASC) of Australia and China University of Mining and Technology (CUMT) have focused on shearer positioning and identified the shearer inertial navigation system, the measurement of longwall retreat and creep displacement, and the backward calibration of the shearer trajectory as three key technologies to obtain accurate shearer positioning information. In underground environments without GPS, due to the characteristics of inertial navigation system (INS) autonomous full-parameter navigation, shearer positioning based on INS is adopted by the LASC and CUMT, and error reduction algorithms are proposed to inhibit the rapid error accumulation of INS. In order to obtain the periodic calibration information when the shearer reaches the end of the longwall face, it is necessary to measure the retreat and creep displacements in order to back-correct the shearer trajectory. Finding a suitable measurement method for this task is challenging, especially in the presence of dust and moisture. The LASC used a scanning laser and FMR 250 microwave radar to measure these two displacements, while CUMT adopted an ultra-wideband (UWB) radar. In terms of the backward calibration method, minimum-variance fixed-interval smoothing (MFS) proposed by LASC and the global optimiza- tion model (GOM) for the shearer trajectory from CUMT are described in detail. The experiment demonstrates that the GOM outperforms MFS in terms of accuracy but requires more computational resources. Therefore, our next research objective is to develop an efficient and accurate algorithm for performing backward calibration on the shearer trajectory.

INTRODUCTION

Longwall mining is a primary method for extracting coal from underground mines. As shown in **Figure 1**, three kinds of mining equipment used in the longwall face are a shearer, an armored face conveyor (AFC), and a roof support system. The shearer moves back and forth along a rail connected to the AFC, while the roof support system maintains the stability of the coal seam roof. Traditionally, the shearer and roof support system are controlled manually, which inevitably causes the rock to contaminate the coal and reduces the mining productivity. In addition, worker safety is greatly threatened because they are directly exposed to the mining worksite. Improving mining productivity, protecting worker safety, and achieving environmental sustainability are the goals that the coal mining industry has been pursuing[1,2]. Longwall mining automation is a mining process that is carried out using mining equipment without the need for manual intervention. It involves the intelligent perception of the mining environment, intelligent control of the mining equipment, and autonomous operation of the mining process[3,4]. Longwall mining automation technology has shown significant potential to achieve those goals through providing shearer positioning, face alignment, horizontal control, seam tracking, visualization and monitoring, and remote control[5,6]. Among them, shearer positioning is a foundational aspect of the autonomous mining operation, and it is a key technology that enables face alignment and horizontal control. Therefore, the accurate positioning of the shearer is of great significance to longwall mining automation.

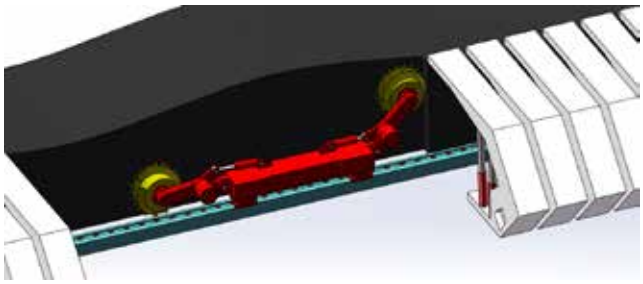
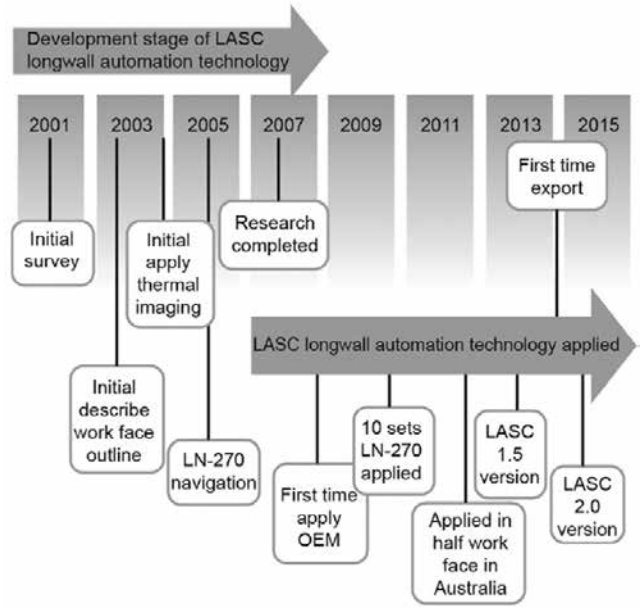


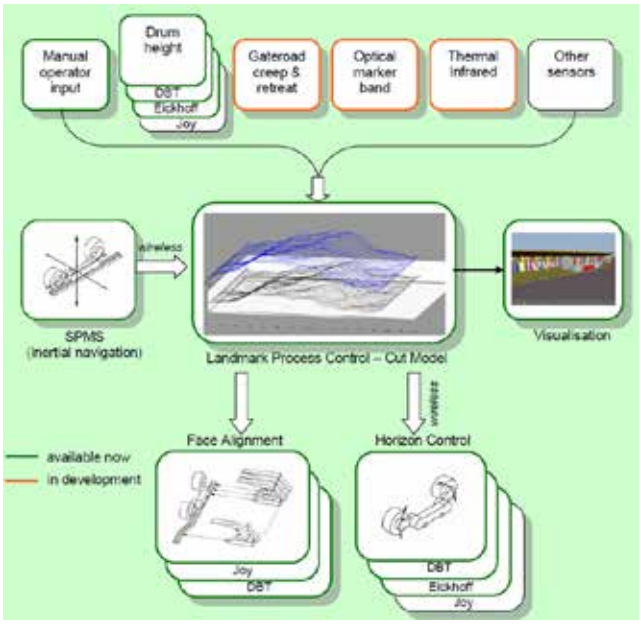
Figure 1: The diagram of the shearer, AFC, and roof support system.

As early as 2001, the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia began developing the longwall automation technology known as the Longwall Automation Steering Committee (LASC). LASC is the abbreviation for the research team responsible for this technology. The LASC can fix the 3D position of the shearer, maintain the straightness of the conveyor and supports, raise the shearer drum automatically, and provide 3D remote monitoring video feeds[7-9]. The technical framework is shown in **Figure 2b**. The latest version, LASC 2.0, has been adopted in 70% of Australia's coal mines. DBT, JOY, and Eickhoff are all licensed manufacturers of LASC. The social benefits of LASC application have contributed to reducing the number of accidents and deaths, and the costs that are avoided as a result are likely to save mining industries millions of dollars each year. In addition, improving the accuracy of longwall mining operations and reducing the amount of waste rock leads to less environmental disruption. LASC technology has great influence on the development of longwall mining automation around the world.

In China, research on the automation of longwall mining commenced at a relatively later stage. Under the support of the National High-tech Research and Development Program (863 Program) and the National Natural Science Foundation of China, our research gzroup at China University of Mining and Technology (CUMT) has devoted significant efforts to the longwall mining automation.



(a)



(b)

Figure 2: The diagram of (a) the development stage of LASC[6] and (b) the technical framework of LASC.

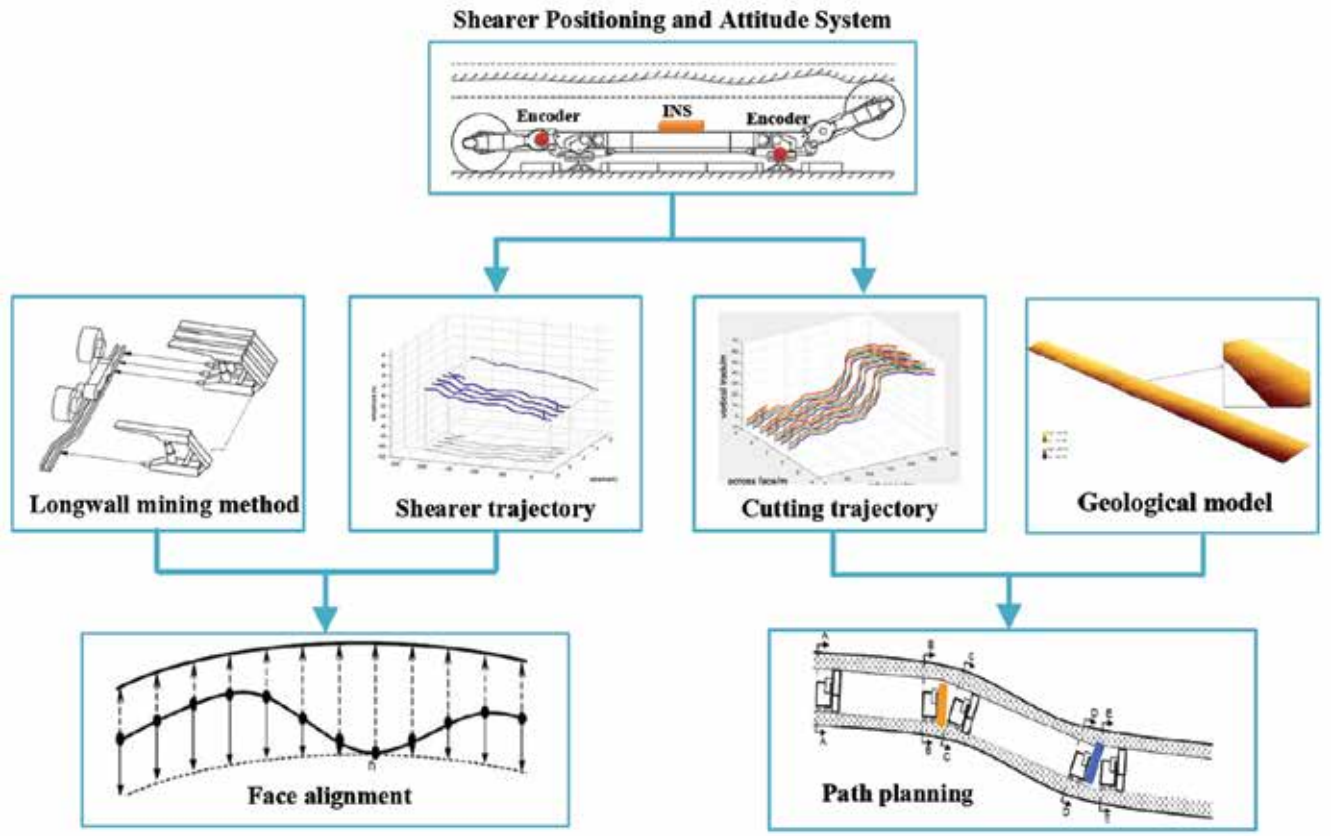
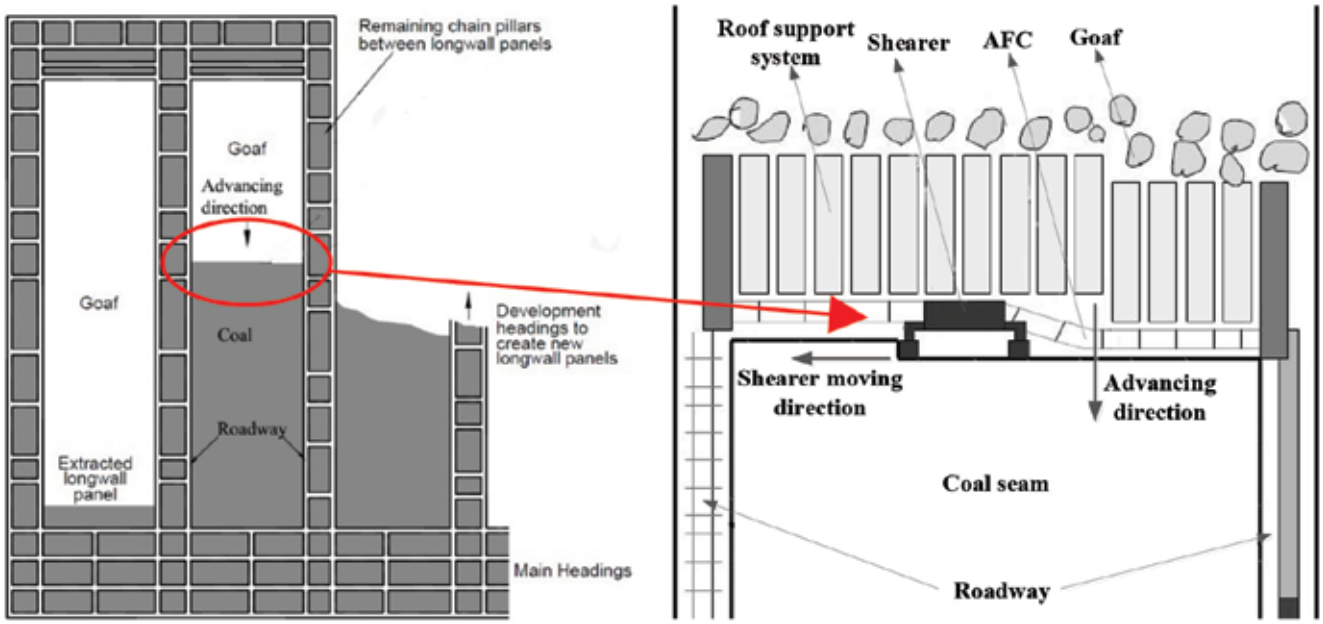


Figure 3: The technical framework of CUMT.

Figure 3 shows the technical framework developed by CUMT for this purpose. The digital model of a coal seam is constructed using drill geological data and the seismic CT detection technique. Combining the digital model of the coal seam, shearer positioning technology is employed to obtain the shearer 3D positioning within the coal seam[10]. Based on this, it is possible to achieve AFC trajectory straightening and shearer cutting path planning. The industrial test was carried out and demonstrated satisfactory performance.

Whether it is for LASC or CUMT, the shearer positioning method plays an important role in longwall mining automation. The shearer inertial navigation system, the measurement of longwall retreat and creep displacement, and the backward calibration of shearer trajectory are three



(a) (b)

Figure 4: Typical plan view of (a) a coal mine and (b) a longwall face[11].

Figure 5: The shearer, AFC, and roof support system across the longwall face in an underground mine.

crucial technologies to acquire the shearer's accurate positioning. Therefore, this paper aims to present an overview of three technologies utilized by the LASC and CUMT, and compares the backward calibration methods proposed by the LASC and CUMT through a conducted experiment.

LONGWALL MINING METHOD

Longwall mining is widely recognized as a highly efficient method for extracting coal from underground mines. In a coal seam, many elongated and narrow roadways are excavated to form the boundaries of several longwall panels, as shown in **Figure 4a**. The roadways serve as a passageway of transportation for coal, equipment, and workers. The sectional area of roadway is approximately 5 × 4 m in general. The coal is extracted from the longwall panel, which is generally 300 min wide and 5000 min long, with a thickness ranging from 1.2 to 8.0 m. At the end of the longwall panel, the shearer, AFC, and roof support system are installed across the longwall face.

As shown in **Figures 4b** and **5**, the shearer moves along a rail associated with the AFC, cutting a 0.8 m-wide slice of coal from the coal seam. The extracted coal is deposited onto the AFC and subsequently transported far away the longwall face. When the shearer is in motion, the hydraulic push arms, which are connected to the roof support system, gradually push a section of the AFC behind the shearer along the advancing direction for the next cutting cycle. In **Figure 6**, the shearer is in operation during n-th cycle, while the AFC behind the shearer has been moved into the n + 1 cycle. When the coal is cut, the roof support systems support the roof of the coal seam. There are approximately 200 roof support systems in a typical longwall face. After the AFC is pushed towards the coal seam, the roof support systems are relocated along the advancing direction. Behind the roof support systems, the collapse of the roof results in the formation of a goaf.

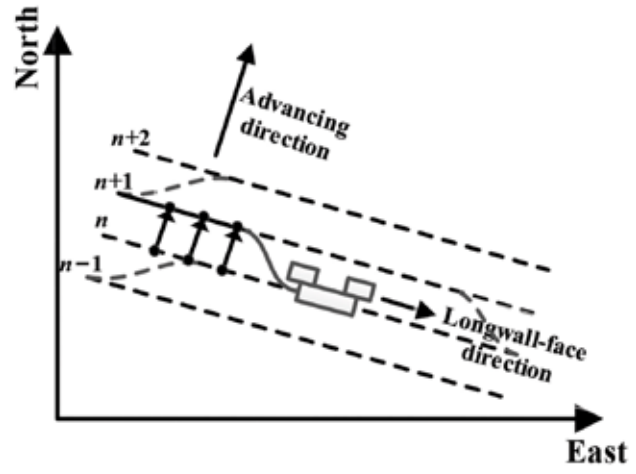


Figure 6: The diagram of the AFC profile as the shearer moves.

SHEARER POSITIONING TECHNOLOGY

The shearer positioning method includes three components, the shearer inertial navigation system, the measurement of longwall retreat and creep displacements, and the backward calibration of the shearer trajectory. Researchers in the LASC and CUMT have been focusing on those three aspects and have acquired good results.

The Shearer Inertial Navigation System

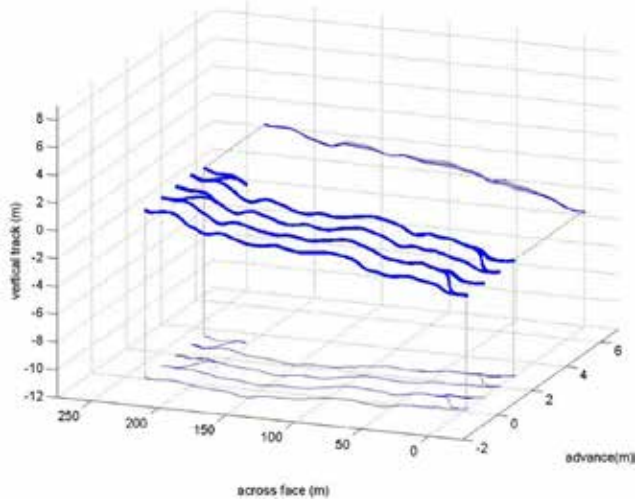
Due to the unavailability of Global Position System (GPS) and BeiDou Navigation Satellite System (BDS) signals in underground environments, the positioning method based on the inertial navigation system (INS) is considered to be a feasible shearer positioning method. The INS exhibits a high level of autonomy, making it widely applied in aircraft[12], ships[13], submarines[14], and so on. The accelerometer and gyroscope serve as the core measurement units to obtain the state of an object. The tri-axis accelerometer measures the linear accelerations of an object with respect to its body reference frame in three orthogonal axes. The gyroscopes are utilised to quantify the angular velocities of rotation of the object with respect to the inertial reference frame. In summary, the navigation algorithm of the INS is founded upon the principles of Newton's laws of motion. The attitude angles are derived through the integration of rotational angular velocities. Subsequently, the rotation matrix, also known as the direction cosine matrix (DCM), is obtained. Through integrating the measured accelerations from the accelerometers and applying the rotation matrix transformation, the velocity and position in the navigation coordinate frame can be determined[15,16].

In order to acquire the shearer position in three dimensions (3D), the LASC has developed a measurement system known as the Shearer Position Measurement System (SPMS). This system utilizes a Northrop Grumman LN270 INS, as shown in **Figure 7a**. The LN270 was installed within an explosion-proof enclosure in the shearer body. In addition to the INS, an odometer, connected to the shearer haulage unit, was required to accurately measure the distance traveled across the longwall face. Afterwards, the second-generation SPMS (SPMS-II) using IXSEA PHINS INS was finished, as shown in **Figure 7b**. Due to the noise and vibration in underground environments, the INS calculation error increases exponentially over time. That is to say, the INS exhibits a very low relative error over short time periods, but over long time periods, the

(a)

(b)

Figure 7: The shearer position measurement system (SPMS): (a) SPMS-I and (b) SPMS-II[17-19].



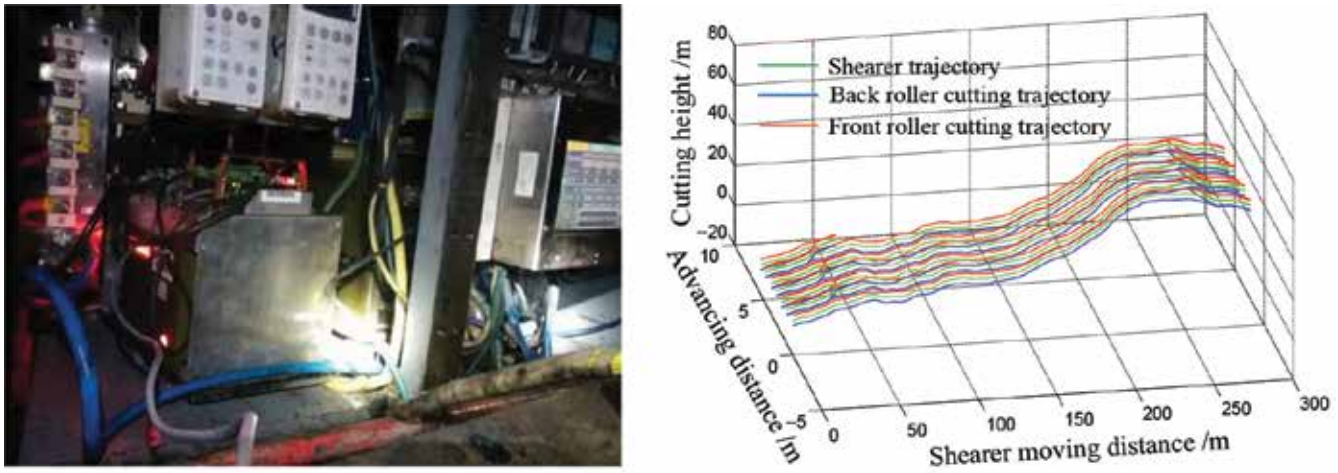
(a)

(b)

Figure 9: The shearer positioning and attitude system (SPAS): (a) SPAS-I and (b) SPAS-II.

error increases dramatically. Based on this, Reid *et al*.[17] employed zero-velocity updating technology (ZUPT) to periodically correct the velocity error during stationary motion for an INS. Furthermore, the development of integrated navigation with an INS and odometer aims to continually enhance performance. After replacing the odometer with a Doppler radar, Dunn *et al*.[18,19] introduced a practical and accurate aiding source. Through analyzing the longwall mining method, Reid *et al*.[20] determined that the horizontal closing distance between two adjacent cutting cycles remained constant. This constant value was found to be instrumental in enhancing the longtime stability of the INS. The 3D path of a shearer in an underground mine, measured using the SPMS, is shown in **Figure 8**.

In CUMT, the authors of this paper built the Shearer Positioning and Attitude Systems (SPAS), including SPAS-I and SPAS-II, as shown in **Figure 9**. The Spatial FOG INS from ADVANCED NAVIGATION provided the attitude angles of heading, pitch, and roll. The axial encoder connected to the travelling unit provided the velocity value of the shearer. The shearer position was then obtained using the dead-reckoning algorithm. The effect of the installation and initial alignment noncoincidence of the INS on the shearer positioning error was analyzed, and a calibration method for the two deviation angles with the two-point method was proposed[22,23]. The current axial encoder is a 12-bit system with a resolution of 1/4096. This implies that the accuracy of INS attitude greatly affects the position error, especially the heading angle accuracy. Based on previous research, the heading angle error was found to increase at a faster rate than the pitch error and roll error over time. Furthermore, it was observed that the heading angle error directly affected the plane positioning accuracy[24,25]. According to the longwall mining method, two constraints on the shearer velocity and position were obtained. Therefore, the dynamic zero velocity update (DZUPT) model[26] and the closing path optimal estimation model[27] were built using a Kalman filter. In order to improve



(a) (b)

Figure 10: The diagram of (a) the underground field test in Shanxi and (b) the shearer trajectory acquired using the SPAS[28].

shearer positioning accuracy, an information filter was proposed to integrate these two models[11]. An underground field test was performed at 18,201 longwall faces in Shanxi Province, China, and **Figure 10b** shows the shearer trajectory acquired via the SPAS.

The Measurement Method of Longwall Retreat and Creep Displacements

In the section *The Shearer Inertial Navigation System*, the utilisation of auxiliary sensors, ZUPT, DZUPT, and kinematics model reduced INS drift error and improved the positioning accuracy. However, due to the lack of periodic GPS calibration, the INS longtime error is still relatively large. After several cutting cycles, the shearer positioning accuracy cannot meet the requirement of the longwall mining automation. According to the longwall mining method, the shearer reciprocates between two roadways along the longwall face. When the shearer reaches the end of the longwall face, the longwall retreat and creep displacements become significant parameters to measure, which can be utilised to back-correct the shearer trajectory after the completion of each cutting cycle. As shown in **Figure 11**, according to the longwall mining method, the retreat displacement is actually the advancing distance of the mining equipment along the advancing direction every time. Due to the different levels of inclination of the longwall face, there will be a height difference between the two ends of the longwall face. When the mining equipment is installed on the inclined longwall face, the force acting on the equipment is not balanced, which makes the equipment slide along the longwall-face direction and produces the displacement of sliding up and down.

In the LASC, Reid *et al*.[20] installed the scanning laser on the roadway conveyor structure linked to the AFC to scan the roadway profile. Accordingly, the first generation of a scanning device with SICK LMS200 as the core sensor and the second generation of an explosion-proof 3D laser scanning device called ExScan have been developed. The current scan was matched to the global map with

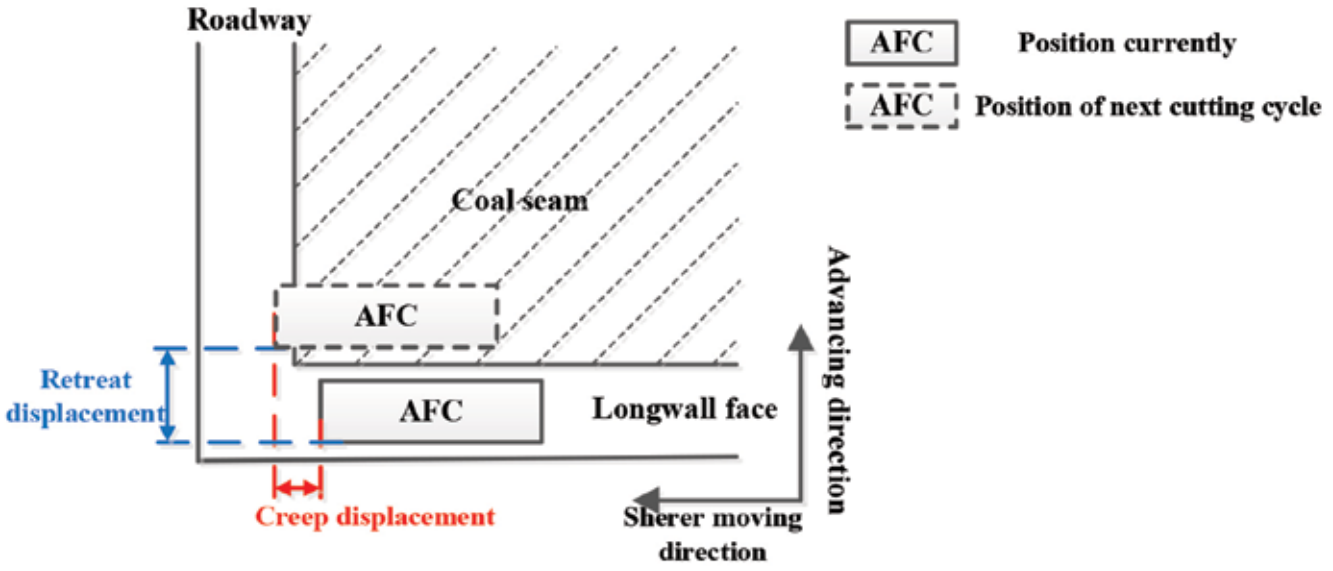


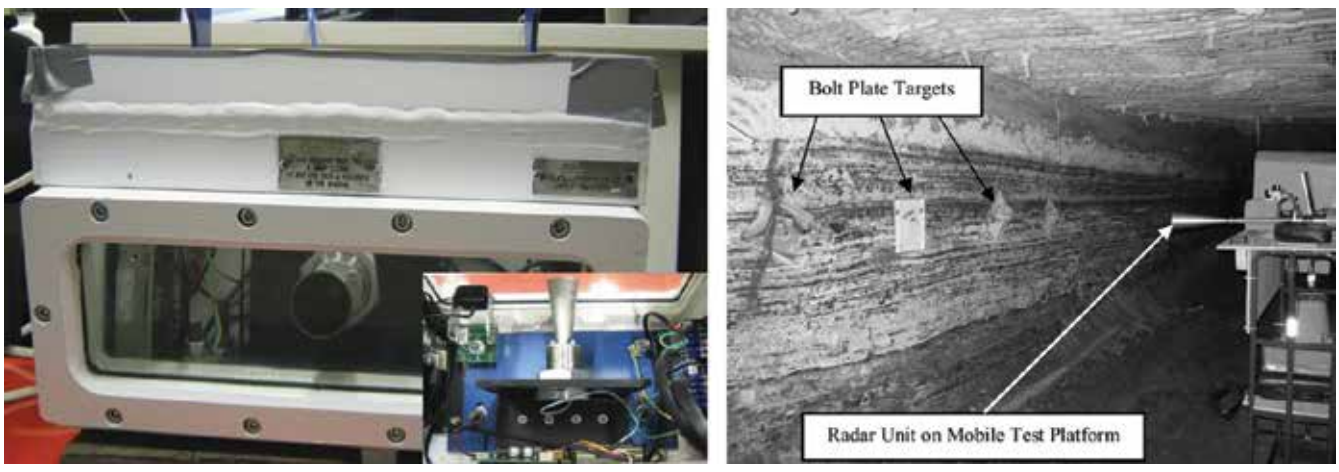
Figure 11: The diagram of the longwall retreat and creep displacements.

(a) (b)

Figure 12: The diagram of (a) the SICK LMS200 scanning laser and (b) ExScan.

the scan-matching algorithm to acquire the retreat and creep displacements, as shown in **Figure 12**. However, the dust and moisture in an underground mine would greatly increase the attenuation and distortion of the laser beam, which affect the laser measurement accuracy. Then, Hargrave *et al*.[29-31] used the FMR 250 radar from Endress-Hauser company in Germany to measure the retreat and creep displacements, and a field test in Australia's Beltana mine was carried out to verify the effectiveness of the proposed method, as shown in **Figure 13**. The radar is sensitive to distance information, and the creep displacement was obtained through measuring the distance between the radar and roadway wall. The number of bolt-plates on the roadway surface represented the position information, thus enabling the measurement of retreat displacement through the recognition of these bolt-plates. However, in the majority of mines, the bolt-plates lack position information, thereby limiting the applicability of this method.

In CUMT, the authors of this paper provided a novel measurement solution with the ultra-wideband (UWB) radar imaging method[32]. UWB radar is characterized by a radar with a fractional bandwidth exceeding 25%. Through transmitting electromagnetic wave signals with a strong ability to penetrate a coal-dust environment, UWB radar can obtain target or scene images all day and in all weather, which has the technical advantage of application in the complex environment at the end of a longwall face. As shown in **Figure 14a**, the radar was mounted on a slide-way, and the slide-way was placed on the roadway conveyor structure connected to the head of the AFC. The radar was moved along the slide-way to image the bolt-plates. Two imaging results were obtained before and after



(a) (b)

Figure 13: The diagram of (a) the Endress-Hauser FMR 250 radar and the (b) field test in an underground mine[29-31].

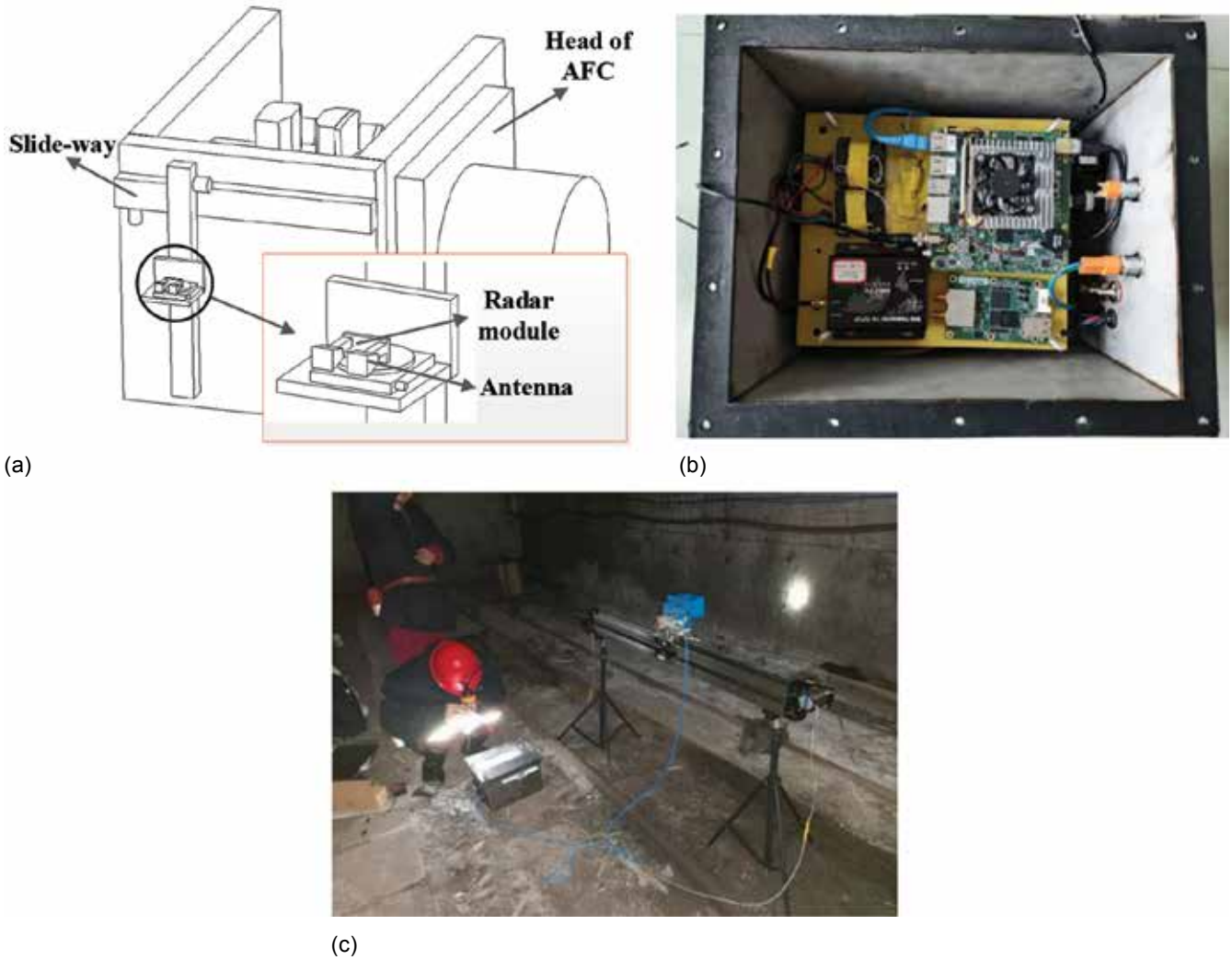


Figure 14: The diagram of (a) the measurement principle, (b) the measurement device, and (c) a field test in an underground coal mine[32].

the movement of the longwall face. Then, the feature-based image registration algorithm was employed to identify the correct-match pairs, and subsequently, the similarity transformation model was calculated to determine the retreat and creep displacements. The measurement device was developed (**Figure 14b**), and the algorithm program including radar imaging and image registration were embedded. The field text was performed in Xuzhuang Coal, China National Coal Group Corporation, and the mean values of retreat and creep measurement displacements were 8.0 mm and 8.6 mm, respectively.

The Backward Calibration of Shearer Trajectory

According to the measured retreat and creep displacements outlined in the section *The Measurement Method of Longwall Retreat and Creep Displacements*, the start and end points of each cutting cycle can be determined. In the LASC, the minimum-variance fixed-interval smoothing (MFS) algorithm was applied to correct the shearer trajectory backwardly when the shearer remains stationary at the end of the longwall face[33]. In fixed-interval smoothing, the estimation of the current state is based on the utilisation of the measurement data from both before and after the current time within the interval. Smoothing is an off-line processing algorithm. Compared with filtering, smoothing can provide better estimation accuracy with the double computation load. The minimum-variance fixed-interval smoothing algorithm is briefly expressed as follows.

Suppose that the system satisfies the state equation and observation equation as **Equations 1** and **2**.

Equation 1

$$X_{k+1} = F_k X_k + B_k W_k$$

where X_k is the state vector, F_k is the state transition matrix, B_k is the noise transition matrix, and W_k is the state noise whose covariance is Q_k.

Equation 2

$$Z_k = H_k X_k + V_k$$

where Z_k is the observation vector, H_k is the observation transition matrix, and V_k is the observation noise whose covariance is R_k.

There are N sample data in the system. The smoothing algorithm has two steps. Step 1: calculating (3) from k = 0 to k = N to obtain α_k. Step 2: calculating (4) from k = N to k = 0 to acquire β_k under the known α_k from (3).

Equation 3

$$\begin{bmatrix} X_{k+1} \\ \alpha_k \end{bmatrix} = \begin{bmatrix} F_k - K_k H_k & K_k \\ -H_k(H_k P_{k-1} H_k^T + R_k)^{-1/2} & (H_k P_{k-1} H_k^T + R_k)^{-1/2} \end{bmatrix} \begin{bmatrix} X_k \\ Z_k \end{bmatrix},\ X_0 = 0$$

Equation 4

$$\begin{bmatrix} Y_{k-1} \\ \beta_k \end{bmatrix} = \begin{bmatrix} F_k^T - H_k^T K_k^T & H_k^T (H_k P_{k-1} H_k^T + R_k)^{-1/2} \\ -K_k^T & (H_k P_{k-1} H_k^T + R_k)^{-1/2} \end{bmatrix} \begin{bmatrix} Y_k \\ \alpha_k \end{bmatrix},\ Y_N = \mathbb{C}$$

where K_k is the gain, which can be given as (5), and P_k is the mean square of the system, which is updated as (6).

Equation 5

$$K_k = F_k P_{k-1} H_k^T (H_k P_{k-1} H_k^T + R_k)^{-1}$$

Equation 6

$$P_k = H_k P_{k-1} H_k^T - K_k (H_k P_{k-1} H_k^T + R_k) K_k^T + B_k Q_k B_k^T$$

Therefore, the estimated output is expressed as

Equation 7

$$\hat{Z}_k = Z_k - R_k \beta_k$$

In CUMT, the authors of this paper proposed the global optimization model (GOM) for shearer trajectory through borrowing the simultaneous localization and mapping (SLAM) technology. The SLAM frame is divided into front-end and back-end procedures[34,35]. The front-end process acquires the environment information using a camera or lidar to realize the map construction. The back-end step is to realize the map optimisation and obtain the estimated pose according to the constraint information from the loop closure. This step is generally implemented using g2o[36] and Ceres-solver[37]. The GOM is described in detail as follows.

The dead-reckoning algorithm is used to calculate the shearer position based on the INS and axial encoder as (8).

Equation 8

$$\begin{aligned} N_k &= N_{k-1} + v_k T \cos\varphi_k \cos\theta_k \\ E_k &= E_{k-1} + v_k T \sin\varphi_k \cos\theta_k \\ U_k &= U_{k-1} + v_k T \sin\theta_k \end{aligned}$$

where N_k, E_k, and U_k are the shearer measurement position in the north, east, and up; v_k is the shearer velocity provided by the axial encoder; T is the sampling period; and ϕ_k and θ_k are the heading and pitch angles measured by the INS. As introduced in the section *The Shearer Inertial Navigation System*, the heading drift error is much larger than the drift error of the pitch. Therefore, this paper only considers the heading drift error. According to the dead-reckoning algorithm, the position error caused by the heading drift in the north (ΔN_k) from $k-1$ to k can be expressed as

Equation 9

$$\Delta N_k = v_k T \cos\varphi_k \cos\theta_k - v_k T \cos(\varphi_k + \Delta\varphi_k)\cos\theta_k$$

where $\Delta\phi_k$ is the absolute drift error of heading angle at k time, which is the sum of relative drift error (e_k) in each sampling period as (10).

Equation 10

$$\Delta\varphi_k = \sum_{k=1}^{k} e_k$$

Expanding ΔN_k into a power series of $\Delta\phi_k$ at $\Delta\phi_k = 0$ yields

Equation 11

$$\Delta N_k \approx H_1 \Delta\varphi_k + \frac{1}{2} H_2 \Delta\varphi_k^2 + \frac{1}{6} H_3 \Delta\varphi_k^3$$

where H_1, H_2, and H_3 are coefficients found in (12).

Equation 12

$$\begin{aligned} H_1 &= \frac{d(\Delta N_k)}{d(\Delta\varphi_k)} = v_k T \sin(\varphi_k + \Delta\varphi_k)\cos\theta_k \\ H_2 &= \frac{d^2(\Delta N_k)}{d(\Delta\varphi_k)^2} = v_k T \cos(\varphi_k + \Delta\varphi_k)\cos\theta_k \\ H_3 &= \frac{d^3(\Delta N_k)}{d(\Delta\varphi_k)^3} = -v_k T \sin(\varphi_k + \Delta\varphi_k)\cos\theta_k \end{aligned}$$

Similarly, the position error caused by the heading drift in the east (ΔE_k) from $k-1$ to k is given as (13).

Equation 13

$$\Delta E_k = v_k T \sin\varphi_k \cos\theta_k - v_k T \sin(\varphi_k + \Delta\varphi_k)\cos\theta_k$$

Equation 14

$$\Delta E_k \approx J_1 \Delta\varphi_k + \frac{1}{2} J_2 \Delta\varphi_k^2 + \frac{1}{6} J_3 \Delta\varphi_k^3$$

where

Equation 15

$$\begin{aligned} J_1 &= \frac{d(\Delta E_k)}{d(\Delta\varphi_k)} = -v_k T \cos(\varphi_k + \Delta\varphi_k)\cos\theta_k \\ J_2 &= \frac{d^2(\Delta E_k)}{d(\Delta\varphi_k)^2} = v_k T \sin(\varphi_k + \Delta\varphi_k)\cos\theta_k \\ J_3 &= \frac{d^3(\Delta E_k)}{d(\Delta\varphi_k)^3} = v_k T \cos(\varphi_k + \Delta\varphi_k)\cos\theta_k \end{aligned}$$

Based on the above analysis, the objective function $F(e_k)$ is defined as

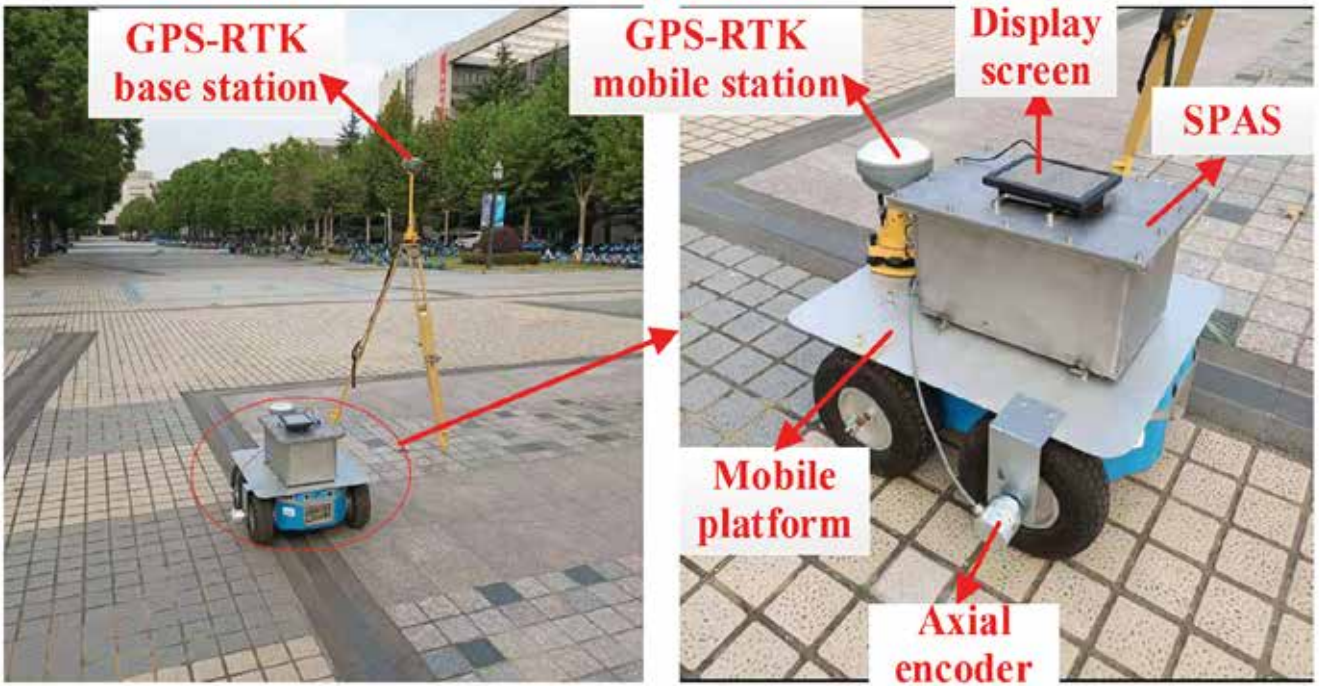


Figure 15: The diagram of the experiment site and device.

Equation 16

$$F(e_k) = \left|(\sum_{k=1}^{m} \Delta N_k) - \Delta P_N\right| + \left|(\sum_{k=1}^{m} \Delta E_k) - \Delta P_E\right|$$

where m is the number of sampling periods in a cutting cycle, and ΔP_N and ΔP_E are specifically described as (17).

Equation 17

$$\Delta P_N = (N_m - N_1) - (N_{end} - N_{start})$$
$$\Delta P_E = (E_m - E_1) - (E_{end} - E_{start})$$

where N_1 and E_1 are the measured position coordinates of the start point in the north and east, N_m and E_m are the measured position coordinates of the end point, N_{start} and E_{start} are the accuracy position coordinates of the start point, and N_{end} and E_{end} are the accuracy position coordinates of the end point. Therefore, the global optimization problem of shearer positioning trajectory is reformulated as solving the minimum value of the objective function $F(_{ek})$ as expressed in (18). In this study, the genetic algorithm (GA) is employed to compute this equation.

Equation 18

$$e_k^* = \underset{e_k}{\operatorname{argmin}}\, F(e_k)$$

The corrected heading angle is obtained via (19), which is used to obtain the shearer optimization trajectory with the dead-reckoning algorithm.

Equation 19

$$\varphi_k^* = \varphi_k + \sum_{k=1}^{k} e_k^*$$

In order to compare the performance of MFS and the GOM, an experiment was carried out as shown in **Figure 15**. The INS was installed at the center location of the mobile platform, and the axial encoder was connected to the wheel of mobile platform. At the same time, a Global Positioning System-Real-Time Kinematic (GPS-RTK) mobile station was installed above the INS, while the GPS-RTK base station was securely fixed on a predetermined location with known coordinates. The measurement trajectory of the base station was used to evaluate the positioning accuracy of the mobile platform. Additionally, it provided the position coordinates of the start point and end point for each cutting cycle. GPS-RTK height measurement exhibited an accuracy of less than 15 mm, while plane measurement demonstrated an accuracy of less than 8 mm. The mobile platform simulated four cutting cycles at a velocity of 0.1~0.2 m/s, and each cutting cycle covered a distance of about 100 m. The calculation period is set as 0.5 s. There were 2013, 2182, 2309, and 2047 sampling data during four cutting cycles, respectively. **Figure 16** shows the comparison between GPS-RTK trajectory and shearer trajectories without processing, with MFS, and with GOM. It was evident that the trajectories with MFS and the GOM exhibited a higher degree of proximity to the RTK trajectory in comparison to the unprocessed trajectory. The position error in the north and east during each cutting cycle were calculated as described in **Figures 17-20**. For both the north and the east, the absolute values of position error with MFS first increased and then decreased. However, there was no such trend in position error with the GOM, which indicated that the GOM could restrain the heading drift well. The maximum position error during four cutting cycles with MFS and the GOM are listed in **Table 1**. The mean errors with MFS in the north and east were 0.1551 m and 0.1920 m, while the mean errors with the GOM were 0.0634 m and 0.0786 m, respectively. Table 2 shows the recorded duration with MFS and the GOM for four cutting cycles. In the GOM, the population size was 20 individuals,

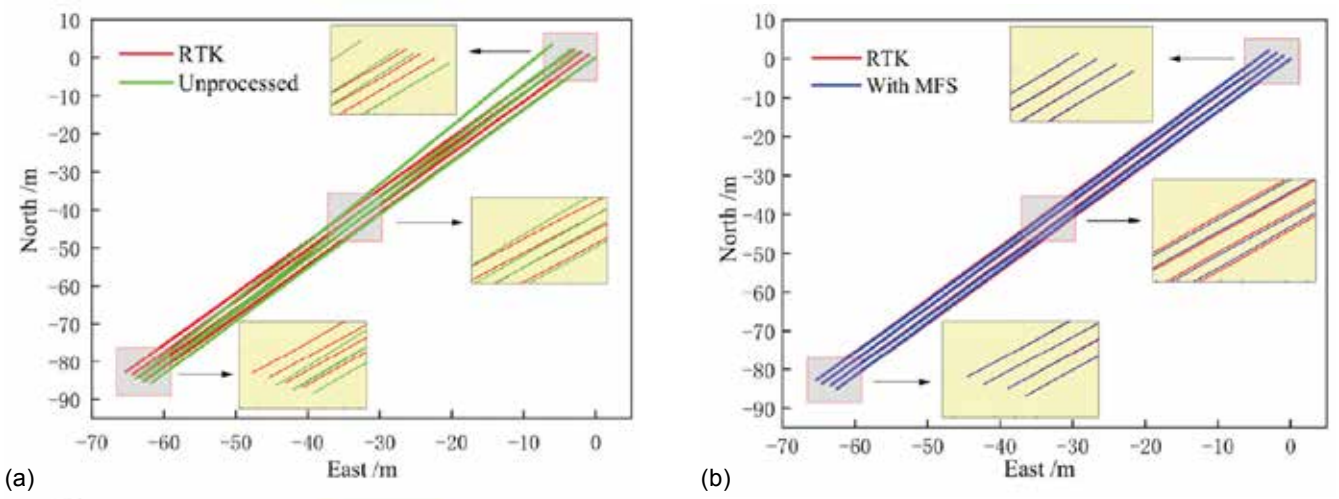


Figure 16: Comparison between RTK trajectory and shearer trajectory: (a) shearer trajectory without processing, (b) shearer trajectory with MFS, and (c) shearer trajectory with GOM.

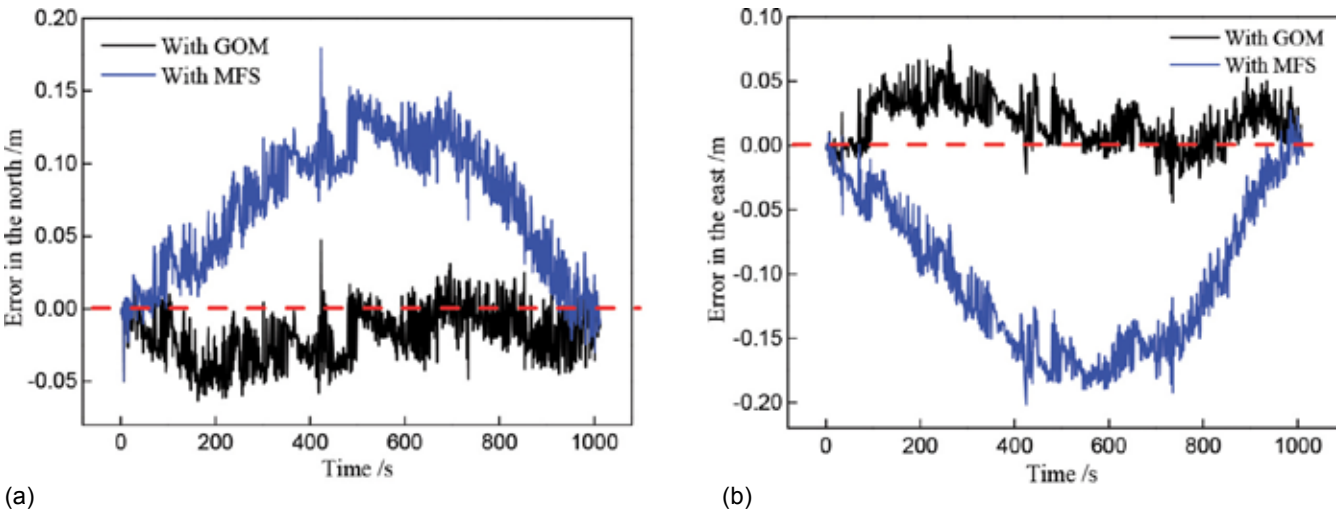
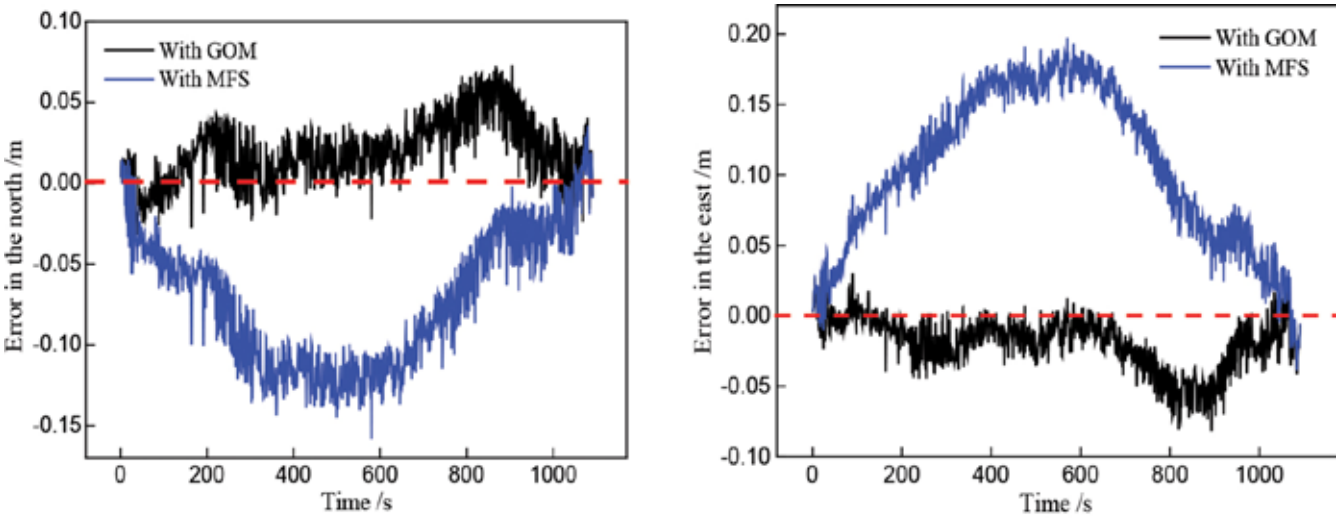


Figure 17: The position error of the first cutting cycle in the (a) north and (b) east.

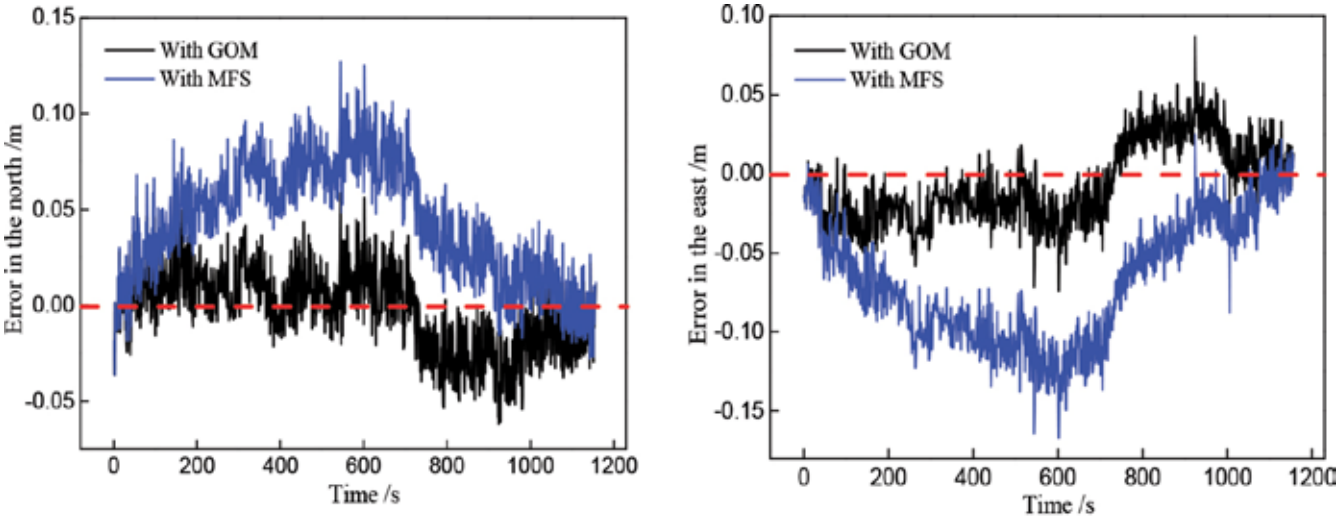
Table 1. The maximum position error (m) with MFS and the GOM during four cutting cycles.

Cutting Cycles	MFS		GOM	
	North	East	Norh	East
First	0.1795	0.2017	0.0631	0.0781
Second	0.1583	0.1975	0.0725	0.0820
Third	0.1272	0.1669	0.0617	0.0868
Fourth	0.1553	0.2018	0.0562	0.0673
Mean error	0.1551	0.1920	0.0634	0.0786



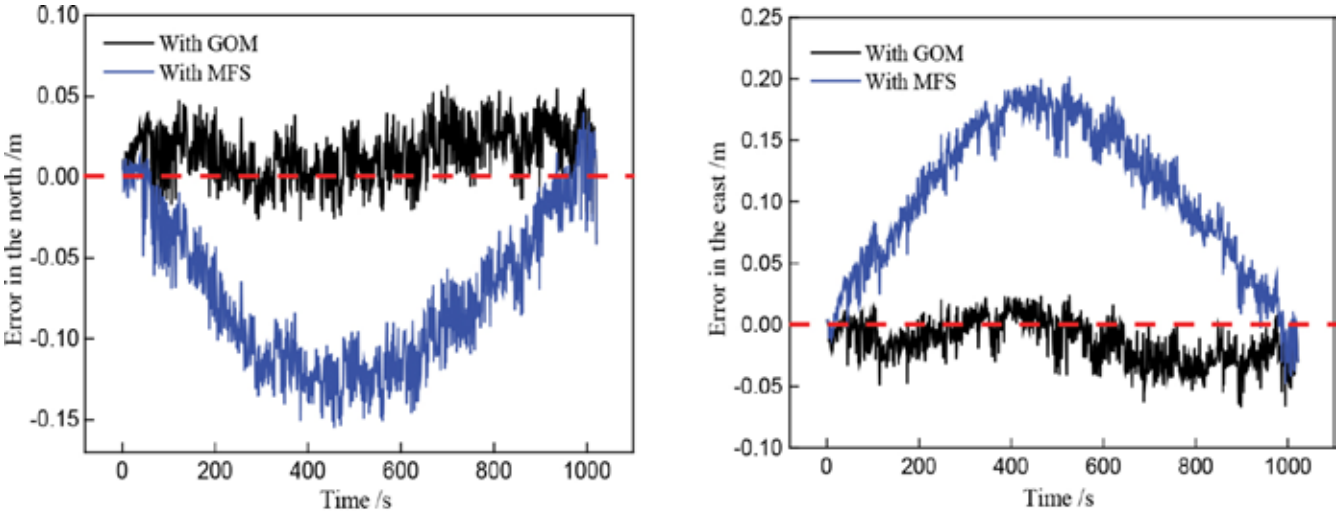
(a) (b)

Figure 18: The position error of the second cutting cycle in the (a) north and (b) east.



(a) (b)

Figure 19: The position error of the third cutting cycle in the (a) north and (b) east.



(a) (b)

Figure 20: The position error of the fourth cutting cycle in the (a) north and (b) east.

Table 2: The elapsed time (s) with MFS and the GOM during four cutting cycles.

Cutting Cycles	MFS	GOM
First	1.6942	202.5673
Second	1.8814	260.5997
Third	1.9999	293.0323
Fourth	1.7098	229.5243

and the number of generations was set to 100. It was easily observed that the GOM took much more time than MFS. In brief, MFS had an advantage in terms of computation load, while the GOM achieved excellent accuracy.

DISCUSSION

The industrial experiments in acquiring the 3D shearer position conducted by the LASC and CUMT have all demonstrated satisfactory performance, which indicates that integrated navigation using the INS and axial encoder is an effective approach for addressing the shearer automation positioning. One difference is that the LASC uses the IXSEA PHINS INS, while the Spatial FOG INS is adopted in CUMT. The cost of the Spatial FOG INS is only one fifth that of the IXSEA PHINS INS. The same performance as a military INS is achieved because the authors of this paper develop a series of error reduction algorithms through fully analyzing the longwall mining method as introduced in Section *The Shearer Inertial Navigation System*.

For the measurement of longwall retreat and creep displacements, the proposed SAR imaging method has two advantages. First, the propagation of radar signals in underground mines is hardly affected by the presence of dust and moisture. Second, this method is an autonomous measurement technology which does not depend on external information. This method images the bolt-plates fixed in the roadway wall as the targets due to their higher reflective intensity. Although the surrounding objects may affect the imaging result, this method still has strong robustness from the final result of image registration.

Compared with MFS, the GOM has better performance in backward-correcting the shearer trajectory. Because it needs to iterate to find the optimal value with GA, the GOM has more working time. In the experiment, there are about 2000 data in each cutting cycle, which takes 4 min for the GOM to complete. If a typical longwall face is 300 m long, the running time of the GOM (more than 12 min) will be greater than the time when the shearer is stationary at the end of the longwall face, which limits its practical application. Therefore, it is an urgent problem to find a backward calibration method with high precision and small calculation load.

CONCLUSIONS

In order to realize the automatic and accurate positioning of shearers in underground mines, the LASC and CUMT adopt the same technical route, which includes three key technologies, the shearer inertial navigation system, the measurement of longwall retreat and creep displacements, and the backward calibration of the shearer trajectory. With INS as the core unit, the LASC and CUMT develop SPMS and SPAS, respectively. At the end of a longwall face, a scanning laser and a FMR 250 microwave radar are used to measure the retreat and creep displacements, and a UWB radar is adopted in CUMT to measure those two displacements with consideration of the complex environment with dust and water vapor. In order to perform backward calibration of the shearer trajectory, MFS and the GOM are proposed by the LASC and CUMT, respectively. Comparisons are made through the experiment, which shows that MFS has better performance in computation load, while the GOM achieves satisfactory accuracy. Next, a high efficiency and accurate algorithm to back-correct the shearer trajectory is our research goal.

AUTHORS

Weiwei Dai
Shibo Wang
School of Mechanical and Electronic Engineering, China University of Mining and Technology, Xuzhou 221116, China; d18649519857@163.com (W.D.); wangshb@cumt.edu.cn (S.W.)

Shijia Wang
School of Mechanical Engineering, Yanshan University, Qinhuangdao 066004, China

REFERENCES

1. Singh, R.D. Principles and Practices of Modern Coal Mining; New Age International: New Delhi, India, 2004.
2. Van Duin, S.; Meers, L.; Donnelly, P.; Oxley, I. Automated bolting and meshing on a continuous miner for roadway development. Int. J. Min. Sci. Technol. 2013, 23, 55-61.
3. Ge, S. Key technology of intelligent coal mining equipment. Coal Sci. Technol. 2014, 42, 7-11. (In Chinese)
4. Yuan, L. Scientific conception of precision coal mining. J. China Coal Soc. 2017, 42, 1-7. (In Chinese)
5. Ralston, J.C.; Hargrave, C.O.; Dunn, M.T. Longwall automation: Trends, challenges and opportunities. Int. J. Min. Sci. Technol. 2017, 27, 733-739.
6. Wang, J.; Huang, Z. The Recent Technological Development of Intelligent Mining in China. Engineering 2017, 3, 439-444.
7. Ralston, J.; Reid, D.; Hargrave, C.; Hainsworth, D. Sensing for advancing mining automation capability: A review of underground automation technology development. Int. J. Min. Sci. Technol. 2014, 24, 305-310.
8. Reid, D.C.; Hainsworth, D.W.; Ralston, J.C.; McPhee, R.J. Shearer guidance: A major advance in longwall mining. In Proceedings of the 4th International Conference on Field and Service Robotics, Lake Yamanaka, Japan, 14-16 July 2003; Springer: Berlin/Heidelberg, Germany, 2003; pp. 469-476.

For further references please refer to : https://doi.org/10.3390/app132212168

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

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

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

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

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

November

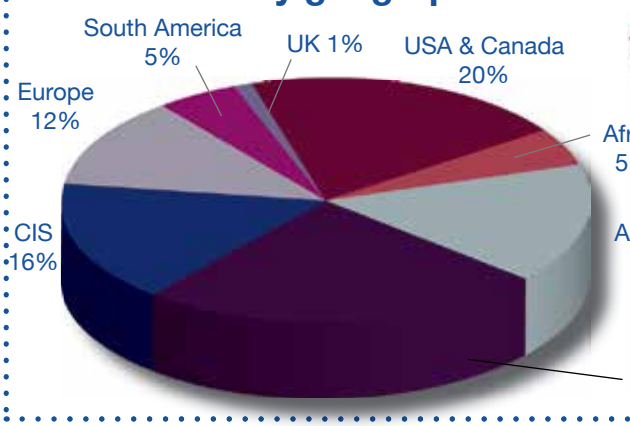
- Hybrid mining machines
- Underground shuttle cars
- Autonomous mining
- Underground conveyor dust suppression
- Screening equipment
- Underground drilling rigs and reinforcement techniques
- Transitioning to a low carbon mine
- Carbon capture and storage
- Shearers
- Draglines

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



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.

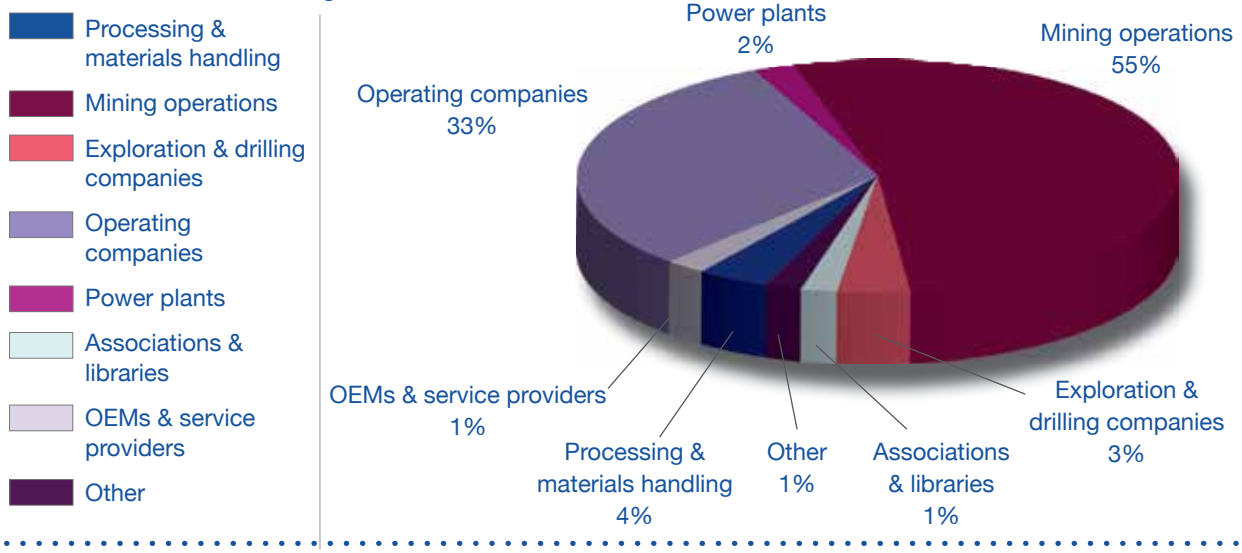
Digital Advertising Rates

Digital product	Total cost	Total cost for all 6 issues	Digital product	Total cost	Total cost for all 6 issues
Front Cover	£2,500	£12,500	**Half page**	£850	£4,250
Back Cover	£2,100	£10,500	**Quarter page**	£500	£2,500
Inside Cover	£2,100	£10,500	**Classified (various sizes)**	£100	£500
Double page centre spread	£2,500	£12,500	**Article placement in Coal International**	£1,200p/p	POA for multiple pages
Full page	£1,700	£8,500			

Please advertise in our digital journals and support us on our mining journey. Download now/today to see the latest issues of our journals. www.mqworld.com

Advertising in Europe and Worldwide contact: gordon.barratt@tradelinkpub.com +44 (0)1909 474258/01777871007

Circulation by business sector



Others include - smelters, steel processes and PR companies

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

The future of coal in the global energy sector

Despite resilient markets, instability presides over the future of coal as energy transition efforts accelerate and regulations tighten on emitters

On the 18th July 2024, Wood Mackenzie hosted the 14th edition of its Coal and the Future of Energy Forum at the Marriott Hotel in Brisbane, Australia.

Wood Mackenzie experts shared their latest insights about the mining, power, steel and renewables industries, as the global energy sector transitions away from coal to a carbon-free world. We also invited a range of industry colleagues to share their views on the markets, the pace of the transition, and the broader investment environment. Following the event, we are sharing some of the key messages.

Fill in the form at the top of the page to download more detailed presentation slides from the event, or read on for a quick overview of the future of coal in the global energy sector.

PARIS TARGETS FALLING FURTHER BEHIND BUT NO TIME FOR COMPLACENCY

Wood Mackenzie's analysts explained that our base case outlook for global emissions reduction is broadly consistent with a 2.5-degree global temperature rise. The most aggressive Paris targets – Net zero or a 1.5-degree temperature rise – are faltering as the weak macro-economic environment exacerbates the sluggish investment into low carbon solutions, and political tensions stymie collaboration. While Wood Mackenzie's base case has not changed in the last 12 months, its pace is at increased risk.

However, the transition will not stop. Electrification of energy consumption is well underway, driving strong power growth in Asia in particular. While beneficial for fossil fuel energy in the near term - as renewables penetration struggles to keep up - there will be negative impacts for thermal coal demand this decade.

Our Australian industry colleagues noted that Australia's latest Integrated System Plan (ISP) was unlikely to be delivered in its entirety. As an example, annual installation of wind generating capacity was running at about 1GW but needs to reach 4GW to hit 2032 targets. The comments align with our analysis of the 2024 ISP which concludes that capture prices under the ISP will be too low - without reform – for renewable generators to make a sufficient return.

ASIA PACIFIC COAL GENERATION TO DECLINE BY TWO-THIRDS BY 2050

Despite the slower-than-expected pace of the energy transition, the Asia Pacific region is going through a power investment boom with US$4 trillion required for new power generation assets in the next decade. In our latest base case outlook to 2050, wind and solar generation is set to grow nearly eight times from 2023, while coal declines by two-thirds.

By 2030, all countries in the Asia Pacific region will reach peak coal power capacity, except for India and Indonesia, where coal continues building into the late 2030s. Nuclear will provide important baseload with capacity more than quadrupling from 105 GW in 2023 to 469 GW in 2050 as thermal generation falls.

Likewise, the cost of renewables will continue to fall in 2024 following the inflation-led surge in 2022, providing further competition to coal through utility scale solar and onshore wind. However, CCS and alternative clean fuels will only make up 22% of coal-fired generation in Asia Pacific by 2050.

GLOBAL THERMAL COAL MARKET WILL DECLINE, LED BY CHINA

The seaborne thermal coal market begins its permanent decline before 2030, with a fall in trade of 60% by 2050. Although demand will continue to grow in SE Asia and India into the 2030s, it fails to offset the rapid decline in coal imports into Europe, China, JKT and, eventually, most of the rest of the world.

The decline in Chinese demand for coal will be one of the key features of the market over the long term with coal generation set to shrink 80% by 2050. In the mid-term we expect China to materially reduce seaborne imports as the country seeks to mitigate the impact of falling demand on its domestic coal mine supply chain. This shift represents a loss of over 300 Mt of annual import demand.

Despite the negative demand trend, there are positives for thermal coal exporters. Coal supply is tight for bituminous coals with major constraints on new high-rank supply as companies, financiers and governments seek to meet their ESG pledges.

Somewhat paradoxically, despite the significant shortening of the cost curve, global marginal costs remain flat over the forecast period. Reserve decline and the reduction in thermal coal project development supports global marginal costs. The loss of reserves means that, in our base case, we still see a need for new project development after 2040.

REFORMS BOOST INDIAN DOMESTIC COAL MARKET

Thermal coal exporters have hopes that India's economic growth will provide a similar boost to import demand as seen in the metallurgical coal sector. Most of India's coal deposits, predominantly lower quality fuels, are found in the eastern and central regions, whereas most of its coal demand centers are in the Western and Northern regions. As such, seaborne imports can be competitive, especially for coastal power plants and other non-power users, since transporting coal across regions presents logistical challenges.

In a bid to rapidly grow its domestic coal supply, India has made significant progress with widespread reforms taking place since 2015, including the Coal Supply Auction policy, and the Coal Mines (Special Provision) Act. Commercial coal mining has seen huge positive changes, after reforms removed end-use restrictions on private investors, leading to a surge in investment, and production. To date, the Indian government has auctioned 107 coal mines with a peak rated capacity of 256 Mt/y. Over the 2024/2024 fiscal year, total domestic coal production breached the 1 Bt level for the first time.

India will rely on thermal coal imports to meet a portion of its growth. We expect absolute increases in demand to be modest, which means India won't be the panacea many hoped it would be.

COMPLEXITY OF STEEL TRANSITION A POSITIVE FOR METALLURGICAL COAL TRADE

Global steel emissions are set to tail off by 30% by 2050 in our base case. With current commercial technologies, deep decarbonisation is only really possible with the widespread switch from coke-based integrated steel production to the use of scrap and DRI in electric arc furnaces (EAFs). Because of the cost and complexity of this shift, we expect a Paris Agreement-aligned emissions reduction path for steel to be improbable.

The situation is made more difficult by a healthy 45% steel demand growth in India and SE Asia, where the coke-based route is being given priority, which will add 150-200 Mt of incremental annual emissions by 2050. In our base case we expect most emissions savings to come from low carbon technologies at existing integrated mills.

Growth in steel in India and SE Asia is a positive for metallurgical coal exporters as these countries rely on imports to meet the vast majority of their needs. This reliance on imports will allow the trade to grow by around 50 Mt by 2050 even while global demand falls as China's steel demand moves into structural decline.

LOW-CARBON TECHNOLOGY OPTIONS NEED TIME AND LOWER COSTS

Under our Net Zero scenario, we forecast an 84% drop in global steel emissions by 2050. We identify China as the largest potential source of reductions? – given its

steel production dominance today – along with mature economies in the European Union, Japan, Korea and Taiwan. By 2050, under such a steep emissions reduction scenario, even India and SE Asia must reduce their emissions by 60-65%.

Low carbon technologies are available, but there is no quick fix. Electric smelting furnace (ESF) technology is being touted as an option as it allows the use of lower grade iron ores as DRI feed. This technology can be combined with existing BOFs or EAFs, reducing capex by around US$150 million compared to a new build DRI-EAF plant.

But the technology's use in steel is still at the pilot stage and its widespread deployment is highly uncertain. Our Australian industry panelists highlighted the role of cheap natural gas as a critical transition fuel in steel decarbonisation, allowing steep emission reduction prior to the later use of zero carbon green hydrogen. Current Australian gas prices make producing low carbon steel uncompetitive.

HYDROGEN-BASED STEELMAKING TO INCREASE ALTHOUGH COST WILL LIMIT PROGRESS

Hydrogen-based steelmaking will be required if steel is to be fully decarbonised but the technology has enormous hurdles to overcome. Our base case includes some 260 Mt of steel produced using hydrogen by 2050 - 12% of global total - but the vast majority comes on line after 2040. A Net Zero scenario would need double this amount, with approximately 42 Mt of green hydrogen to feed DRI plants or be injected into blast furnaces.

Green hydrogen requires green renewable power. One of the major constraints to a Net Zero scenario would be the significant renewable power capacity required globally to produce green hydrogen – some 1600 GW – which represents about 75% of current global installed renewable capacity.

The cost to produce green hydrogen is a major constraint. Costs are need to reduce by 60% for hydrogen-based steel to compete with other steel-making processes. Government/tax-payer support will be required, as will the establishment of a wider spread hydrogen economy including more hydrogen offtakers in order to build momentum. The 17 July 2024 announcement from Fortescue Future Industries regarding its hydrogen business, just one day prior to the forum, highlighted that further work needs to be done in this sector to pave the way for a true hydrogen revolution.

MINE SUPPLY STILL A KEY RISK FOR METALLURGICAL COAL MARKETS

2024 started as a positive year for global supply. New US longwall projects dominated a healthy increase in coal capacity of around 10 Mt in 2024. Australia also looked likely to start a long-awaited recovery in exports after a drop to 151 Mt in 2023, from a record 188 Mt in 2016. But accidents at the new Longview operation in the US and Grosvenor underground mines in Australia this year have reminded us of the numerous challenges facing supply.

Longer term, the availability of premium hard-coking coal (PHCC) is a major concern to international steel makers. Wood Mackenzie's coal supply asset data suggests a net drop in premium low volatile HCC supply by 2027, compared to 2023. Premium mid-volatile HCCs can see net growth but we estimate it will be limited to 15-16 Mt above 2023 levels in the long term. This trend suggests steel mills will have to adjust coke blends over time, relying more on lower quality metallurgical coals, and will likely see a growing price differential between premium coals. India is focusing heavily on stamp-charged coke ovens, a strategically sensible move widening the quality of feed coals that can be used in coke-making.

The investment environmental not ideal. We heard from industry panelists that in addition to the broad uncertainty in the economy and in emissions reduction targets, government regulation was making it harder to invest in new coal. Coal suppliers expressed a view that changes to royalties and related policies had reduced their willingness to invest in Australia, with the US and Canada considered better options for miners and steel companies looking to vertically integrate.

Mine decarbonisation is a priority. We learned that EU steelmakers, in particular, were actively looking at supply chain emissions, as they align with CBAM requirements. However, outside Europe, mine emissions – classified as upstream scope III from a steel mill's perspective – are not currently a target for steel mills. In Australia, steel mills are focused on scope I and II emissions.

Robin Griffin
Vice President, Metals and Mining Research

MinExpo 2024..... The Good and the Great

It is hard to believe that 4 years have passed since the last MINExpo show, however, with all pandemic restrictions and fears a thing of the past we now welcomed MINExpo 2024, as always we looked forward in anticipation to viewing a veritable mine-fest of innovation, gigantic machinery and the opportunity to collaborate, discuss, challenge, learn and engage current thinking, practices and the way forward for the industry, with like-minded individuals.

The National Mining Association (NMA) is the only national trade organization that serves as the voice of the U.S. mining industry and the hundreds of thousands of American workers it employs before Congress, the federal agencies, the judiciary and the media, advocating for public policies that will help America fully and responsibly utilise its vast natural resources. *Gordon Barratt* representing both *Mining & Quarry World* and *Coal International* never fails to be impressed by the technological advances in mining showcased at this event and explores in person every level of mining, sourcing and investigating cutting-edge concepts and new-to-market equipment, however, an almost impossible task would be to try to cover all the "good and the great" who attended this show, so…here is an oversight of some of the key companies exhibiting this year.

MONTABERT

During the MinExpo 2024 show it was a great pleasure to have a detailed discussion on Montabert breakers with Aaron Scarfia General Manager of Montabert USA, what Aaron and his team don't know about breakers, probably isn't worth knowing I was given a full tour of their products on display and at the end of it all I was a little wiser and more knowledgeable about these beasts of the mining and construction industry. Since 1921, Montabert products have been produced with a commitment to designing methods and solutions focused on productivity, reliability and safety.

Continuous investment in research and development has resulted in the delivery of technology products that revolutionize the construction and demolition industries. For almost 100 years, Montabert products have led these industries, with three to five patents a year.

Montabert products have been produced with a commitment to designing methods and solutions focused on productivity, reliability and safety.

Montabert drifters result from years of experience in hydraulic rock breakers and drifters design and manufacturing. In-depth knowledge of shock wave transmission and percussion mechanism theory has allowed engineers to be the first to develop new concepts such as hydraulic dampening and progressive blow energy.

DRIFTERS

Montabert drifters are the result of years of experience in hydraulic rock breakers and drifters design and manufacturing. In-depth knowledge of shock wave transmission and percussion mechanism theory has allowed engineers to be the first to develop new concepts such as hydraulic dampening and progressive blow energy.

CPA DRILLING ATTACHMENTS

With Montabert CPA drilling attachments, your hydraulic excavator becomes a multi-purpose tool for loading, trenching and blasting.

The use of innovative high-performance technology in product design and manufacturing makes Montabert equipment the most efficient and reliable choice for customers around the globe.

With a network of 150 dealers around the world, you will always find a Montabert-certified partner close to you to provide the best service and solutions as they have a comprehensive support team that can provide help in any aspect.

The ZJ32 drill and ZB31 bolter expand product offerings to meet customer demands

A Komatsu ZJ32 designed for underground mining applications.

KOMATSU LAUNCHES A NEW LINE OF MEDIUM-SIZE CLASS FACE DRILLING RIGS AND BOLTERS

Underground hard rock mining operations looking for versatile solutions now have two more options. Komatsu is excited to introduce the new Z3 series of medium-size class development jumbo drills and bolters to its lineup, further broadening Komatsu's selection of offerings for the underground mining industry.

The Z3 machines are built on a universal platform and designed with a focus on modularity and efficiency. This focus offers improved productivity that can help reduce service and maintenance costs across operations. The Z3 also boasts universal operator controls, simplifying user adoption and increasing training efficiency. The new series expands Komatsu's current underground hard rock offerings by adding the ZJ32 and ZB31 medium-size class drill and bolter.

Key features include innovative technology, such as a newly designed ground support installation system developed in collaboration with JENNMAR that utilizes their J-LOK P pumpable resin. In addition, the machines' drilling attachments have limited moving mechanical parts and offer a simple design for smooth operability, resulting in reduced cycle times and increased drifter uptime compared to competitors in the same size class.

"Our Z3 product line was designed to meet the evolving demands of our underground hard rock mining customers," said Johan Kempe, Product Director, Underground Drills, Komatsu. "The common platform on which both machines are built enables the interchangeability of parts and service, boosting operational productivity for customer operations."

In the near future, additional battery and intelligent machine control models of the Z3 series will be added to the lineup to provide customers with a comprehensive range of offerings to meet their demands. This product family of diesel and battery-powered machines will offer innovative solutions to support underground mining operations with a pathway toward autonomous operations.

For a firsthand look at the new Z3 series of products and other advanced mining solutions, visit Komatsu at booth 7132 in Central Hall at the Las Vegas Convention Center from September 24 to 26.

KOMATSU EXPANDS HARD ROCK CRUSHING LINEUP WITH THE INTRODUCTION OF THE HRX800

Komatsu is proud to announce the expansion of its hard rock crushing equipment portfolio with the introduction of the HRX800 sizer, an innovative solution designed to enhance efficiency and productivity while reducing waste. This product line extension underscores Komatsu's commitment to providing customers with robust, high-performing machines that drive production growth and add value to their mining operations.

Komatsu's comprehensive crushing lineup includes feeder breakers, reclaim feeders, mobile crushers and sizers, all engineered to meet the demanding needs of modern mining operations.

The HRX800 joins an expanded portfolio that includes the HRX1000

The HRX800, launching at MINExpo 2024, represents the next step in Komatsu's evolution of crushing technology. Designed for hard rock applications, the HRX800 is a smaller-scale alternative to the HRX1000, providing the same high capacity and efficiency in a more compact form. This sizer is ideal for both underground and surface installations, offering the benefits of fines reduction in demanding applications of hard abrasive minerals or wet and sticky material.

"We are excited to introduce the HRX800 to our customers," said Brandon Phillips, Global Product Manager of Sizers and Feeder Breakers at Komatsu. "The HRX800 is designed to push the envelope on where sizers can be successfully applied, delivering the power and performance our customers expect from Komatsu while offering the flexibility needed in today's dynamic mining environments

The HRX1000, a standout in Komatsu's crushing lineup, will be on display at the upcoming MINExpo 2024 in Las Vegas. This primary crusher is designed to accept run-of-mine materials and crush them to a size suitable for conveyor transport, making it a crucial component in mining operations that demand high production capacity. The HRX1000's innovative pick technology efficiently breaks down minerals in tension, reducing the need for multiple crushers and lowering operating costs. Its versatility makes it an invaluable asset in a wide range of mining applications.

For a firsthand look at the HRX1000 and to learn more about the launch of the HRX800, visit Komatsu at booth 7132 in Central Hall at the Las Vegas Convention Center from September 24 to 26.

KOMATSU SHOWCASES COMMITMENT TO THE COAL INDUSTRY

Komatsu reaffirms its dedication to supporting coal customers and remains steadfast in its long-term commitment to the industry. With over 100 years of experience and a robust roadmap for the future, Komatsu continues investing in cutting-edge automation, innovative products and service solutions to help its customers achieve peak performance, safety and sustainability.

Investments in automation and innovation provide customers with products and services to meet their needs

Komatsu's continued evolution of automation solutions bolsters its dedication to the coal industry's future. Using advanced, web-based controls, Komatsu's Longwall Command and Control is removing operators from hazardous environments and enabling remote management of equipment. This solution allows for centralized management of mining equipment and brings consistency, productivity and safety to a new level. In step with advancements in longwall, Komatsu is driving innovation in room and pillar mining with industry-leading continuous miner automation.

Highlighting its latest advancements in longwall mining product solutions, Komatsu is featuring the next-generation Joy J7500 shearer ranging arm. The J7500 ranging arm offers greater productivity, power and reliability over its J525 predecessor. A longer arm enables an improved tailgate cut past, up to a 50% increase in motor power and increased geartrain life. Notable maintenance improvements, such as gob-side water seal access and a modular planetary subassembly, enhance efficiency.

Additional longwall mining features, including the latest in AFC pan lines, Powered Roof Support (PRS) Design Services and Electrohydraulic Control Systems, reinforce Komatsu's investment in coal mining solutions.

Further enhancing its customer commitment, Komatsu is investing in and expanding its service offerings. Through Komatsu's Application Engineering Services offering, its experienced mining engineers are positioned to assist customers in optimizing equipment use, finding efficiencies and elevating mine productivity. The full-service support suite also includes quality parts and rebuilds, effective training solutions, responsive field service and insightful machine analytics to meet and exceed customer expectations.

"Komatsu remains fully committed to the coal business, and we will continue to invest in the technologies that help our customers operate safely, productively, and sustainably," said Dan Spears, Soft Rock AMNO Vice President at Komatsu. "From our latest machines to advancements in automation, we are dedicated to

providing innovative products and services that meet the evolving demands of the industry." With a focus on long-term partnerships, Komatsu remains a trusted name in coal mining and is dedicated to advancing the industry through products, services and technological innovation.

Komatsu reaffirms its dedication to supporting coal customers and remains steadfast in its long-term commitment to the industry. With over 100 years of experience and a robust roadmap for the future, Komatsu continues investing in cutting-edge automation, innovative products and service solutions to help its customers achieve peak performance, safety and sustainability.

Cat® wheel loaders are some of the most productive machines in your operation – working wherever you want, whenever you want them. Built for efficiency, they give you the mobility and flexibility you need to optimize your loading and hauling operation and lower your overall costs. You count on them to boost your productivity – and your profitability.

That's why we make sure Cat wheel loaders not only help you meet your productivity targets but exceed them. When they're not loading material, their versatility and mobility makes Cat wheel loaders valuable support machines. And with industry-leading service life and uptime, they'll keep your operation productive for years to come.

Cat large wheel loaders deliver optimized power for fast cycle times and continuously high bucket fill factors on every dig cycle. No matter the size, they have the capability to quickly dig through material and the power to lift full buckets. They're proven to deliver industry-leading availability, working around the clock to keep production moving. And they come with a variety of ground engaging tools to help you make the most effective use of your machine, no matter the conditions on your site.

Whether you're ready to integrate your first basic technology product or well down the path toward autonomous mining, there's a Cat® MineStar™ Solution for you. MineStar has the ability to track, monitor, automate and manage all types of assets — from people to production machines to light vehicles on site. Whether you deploy a single technology or a multi-purpose solution, you can expect a safer, more productive and more efficient operation.

Haver & Boecker Niagara

Haver & Boecker Niagara is a leader in screening and pelletizing and has a mission to deliver the best of these technologies to customers in the mining, minerals, aggregates, cement, construction materials, fertilizers and salt industries. With deep roots and years of experience in these industries, they use innovative and shared technologies to effectively meet the needs of customers around the world.

Washington Samuel Tyler founded The W.S. Tyler Company in Cleveland, Ohio in 1872 with the basic operating principle, "our products are not an end in themselves, but a means by which our customer can accomplish something useful and profitable."

In 2019,Haver & Boecker Niagara launched a new, global brand for mineral processing technology, representing three manufacturing companies in Germany, Brazil, and Canada, but also their mineral processing expertise throughout the world.

It combines the long-term success of Haver & Boecker and W.S. Tyler with worldwide engineering and application expertise to help customers address their screening challenges more efficiently and more profitably than ever before. Their goal is to offer a complete portfolio of innovative mineral processing technologies to better meet the needs of customers.

Haver & Boecker Niagara is more than merely a name, it represents their heritage and our legacy, both in the past and future.

The Niagara F-Class vibrating screen offers the ideal solution for challenging screening applications requiring consistent performance, load independence and minimal vibration transmission into the structure.

FEATURES & BENEFITS

- Dynamically balanced design eliminates dynamic loads transferred into the structure to allow for multiple machine installations.
- During overloading, surging and starting and stopping under load, the mounting system, drive and base frame maintain process reliability.
- Double eccentric, four-bearing shaft assembly enhances positive circular motion, ensuring the most effective screening action while minimizing blinding and pegging.

Niagara F-Class Eccentric Inclined Screen

- Customized with cambered or flat decks to accommodate virtually any combination of side-tensioned or modular screen media.

- Side-tensioned deck set-ups incorporate the Ty-Rail™ quick-tensioning system, which cuts screen change-out times in half.

Niagara XL-Class High-Capacity Linear Screen

The Niagara XL-Class vibrating screen combines advanced exciter drive technology with a wide body to offer producers high-capacity screening action up to 15,000 tons per hour. It is intended for high tonnage production rates, yet designed for low maintenance, easy operation and unmatched reliability.

Each machine is custom-designed to its specific application using Finite Element Analysis to predict the high-stress areas and natural frequencies of the vibrating screen.

BODY DESIGN

- Optimized to customer requirements with application-specific body design – supported by Finite Element Analysis.

DECK OPTIONS

- Large deck sizes maximize feed rates.

- Available with flat deck for modular screen media panels, including pin & sleeve, snap-in, groove or bolt-down fastening systems; or with a cambered deck for side-tensioned screen media with a single or double crown; or end-tensioned screen media.

- Every side-tensioned deck is engineered with Ty-Rail, a patented quick-tensioning system designed to reduce change-out time by half.

- Side-tensioned deck set-ups incorporate the Ty-Rail™ quick-tensioning system, which cuts screen change-out times in half.

SIDE PLATES

- Fully-bolted side plates without welding eliminate cracking and extend machine life.

MOTOR SUPPORT

- Overhead, bridge-mounted drive system does not interfere with the material flow path maximizing reliability and extending maintenance intervals.

NEGATIVE SLOPE

- A slope from -3 to 10 degrees allows the force of gravity to keep the water back while the linear action moves material down the deck allowing for more efficient separation of fines from the coarse material and maximizing production.

J.H. Fletcher & Co. is one of the top global producers of custom underground mining equipment. The company has engineered and manufactured solutions since 1937, creating a diverse product line. Fletcher roof bolters are world renowned and accompanied by an entire product line of technological machinery focused on worker safety and productivity in underground mining. At the core of Fletcher, is the value in what their customers say. Since opening for business, Fletcher has been answering some of underground mining's toughest questions. Fletcher provides an atmosphere for an open dialogue with customers to ensure their operations are reaching.

"Our goal is to manufacture equipment for underground mining that increases safety and production through engineering innovation, quality control, experienced service and ownership stability." J. Robert Fletcher

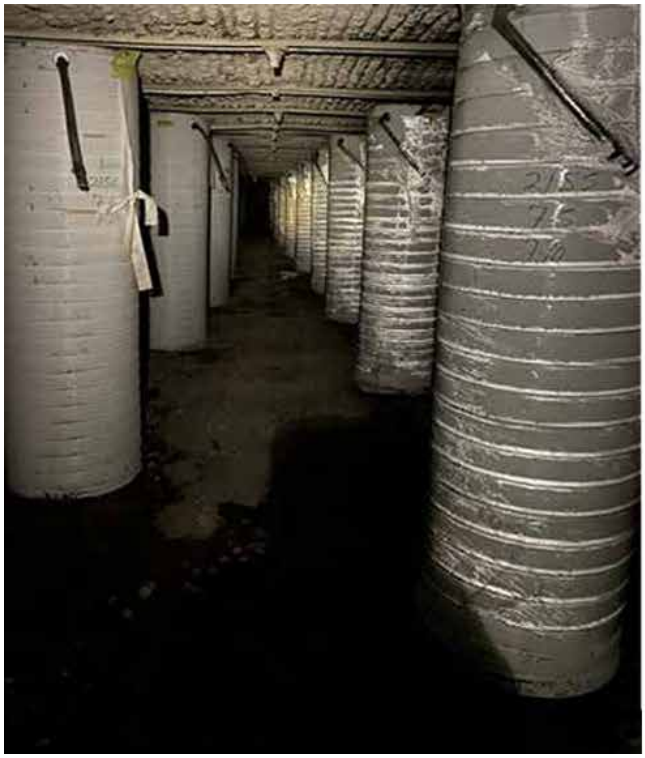
The Fletcher PAN-DR model bolter is specially designed to control inby roof and face while preparing for longwall moves. Can ,mount on shield mover and use as a utility bolter between moves. This machine can reach seam heights as high as 16'.

JENNMAR has been an innovative leader in ground control for the mining industry for more than forty years. Their brand of affiliates provides the ability to offer a complete range of complementary ground control products and services ensuring quality, efficiency and availability, resulting in reduced costs, reduced lead times and increased customer satisfaction. Their contribution to the mining and tunnelling industries is second to none providing customers with a range of products and services

JENNCHEM is the world's largest installer of underground standing support and ventilation control devices, pumped from the surface of mines and tunnels. JENNCHEM designs, delivers, and provides on-site services and support for chemical roof support, rock stabilization, and ventilation sealing products to the mining and underground construction industries.

IMMERSIVE TECHNOLOGIES LAUNCHES "WORLD FIRST" UNDERGROUND MINING SIMULATOR TECHNOLOGY AT MINEXPO 2024

The Immersive Technologies IM360+ was unveiled for the first time publicly at MINExpo, along with never before seen visual system innovations to drive value for underground miners. This solution is designed for underground miners, who often face unique challenges in equipment operator training.



J-CRIB®, a pumpable standing support, provides significant strength and logistical advantanges over traditional coal mine standing support.

Ulra-X Foam is a two-component grout tht is intended for, strata consolidation, coal face reinforcement, and large or small cavity filling.

Equipped with a best-in-class visual system, the IM360+ is the first underground mining simulator to combine stereoscopic 3D, photo-realistic graphics and RealView™ head tracking technology. The IM360+ delivers realism and training value at a level not previously seen by the underground mining industry. The platform builds on the huge success of previous Immersive Technologies platforms that have become the global standard in the mining industry over the past 30 years, training over 250,000+ mining equipment operators across 51 countries.

The IM360+ offers:

- **High Fidelity** – Class-defining 3D stereoscopic display system with true to life graphics delivers depth perception and sensory immersion at the highest levels possible.

- **Reliability & Asset Life** – Designed to operate continuously in harsh mining environments, the IM360+ utilizes professional grade components with extremely

J-SEALis a specialized foaming cement which can be used for backfilling behind steel sets or other general backfiling applications in coal or hard rock mining.

JENNCHEM's 120 psi. Mainline J-SEAL is MSHA approved and can be used with a variety of form designs including wood, concrete block, props and mesh.

high uptime. The platform is based on the most durable design in mining simulation that has a proven asset life of 10+ years.

- **Training Value** – Providing best-in-class training value and continuous improvement capability. The IM360+ incorporates new technologies designed to increase training retention and trainer efficiency. You can expect the highest level of skills transfer to the job in the shortest time possible, creating real operational value.

- **Safety & Comfort** – The IM360+ incorporates best-in-class safety and comfort with air conditioning and heating capacity for the most extreme environments, zero trip ultra-low profile motion platform, and positive pressure airflow system to prevent dust entering from the mining environment.

"Our close collaboration with mining companies paired with our extensive mining technology experience is a catalyst for innovation to solve real mining challenges. At MINExpo 2021 we launched the PRO5 for surface mining and the uptake has been massive due to the training value of stereoscopic 3D and true to life graphics. We knew that underground miners needed a similar capability, so we launched the IM360+ at MINExpo 2024. This is another big step towards our mission to make resource companies measurably safer and more profitable."

Immersive Technologies' Advanced Equipment Simulators are the mining industry's benchmark solution for operator training and workforce optimization. These platforms have an unparalleled track record in the delivery of quantified safety, productivity and unscheduled maintenance improvements, including verified real results by **BHP Billiton, Rio Tinto, Vale, Glencore, Barrick, Newmont, Freeport-McMoRan and Anglo American.**

This track record of innovation and customer success has led to Immersive Technologies being the industry's leader in innovation and the preferred partner with a dominant market share across simulation of all major mining OEM equipment.

- 90% of the World's top 10 mining companies
- 80% of the World's top 20 mining companies
- 360+ Global Mining Operations supported

Caterpillar: Showcasing Solutions for the Mines of the Future

The Caterpillar MINExpo 2024 experience immersed visitors into the mine site of the future—showcasing industry-leading technologies, advancements in the energy transition and customized solutions designed to increase efficiency, safety and profitability.

The planned 2024 exhibition reinforced Caterpillar's position as a leader in mining technology with proven results in autonomy and automation and demonstrated progress in greenhouse gas reduction technologies.

"Caterpillar's legacy is to deliver an exceptional experience at every job site through customer focused solutions and services," says Denise Johnson, Caterpillar Resource Industries' group president. "As our exhibit shows, together with our customers, we are mining better, smarter and

safer. And this is just the beginning of our closer-than-ever before collaborations with customers."

SUPPORTING THE ENERGY TRANSITION

The company's latest innovations to support the energy transition — like the 372-tonne (410-ton) Cat® 798 AC Mining Truck configured for autonomous haulage with Cat MineStar™ Command for hauling.

"We believe systems, such as Command for hauling, are essential to optimize mine site performance, both with our current product line and as we introduce new offerings like our battery electric solutions," comments Marc Cameron, senior vice president, Caterpillar Resource Industries. "Autonomous technology will help monitor and orchestrate the complex balance of onboard energy, available charging assets and production targets to achieve the lowest operating costs."

Two Cat underground load-haul-dump (LHD) loaders on the show floor offer reduced emissions. The Cat R1700 XE Underground Loader features battery-electric propulsion that produces zero exhaust emissions and generates less heat than a reciprocating engine powered model. And the Cat R2900 XE Underground provides a high efficiency switch reluctance electric drive system that meets the mining industry's needs for bigger payloads, faster loading and lower emissions.

Also on display will be a 12.2-m-long (40-ft-long) PGS 1260 HD Energy Storage System (ESS) module, which offers energy storage for charging battery electric machines, and the Cat MEC500, which provides mobile equipment charging for the underground mining industry.

"Since MINExpo 2021, our teams have made incredible progress with the development of our electric technology and supporting solutions," comments Brian Weller, vice president of electrification, Caterpillar Resource Industries. "We have been working side-by-side with select customers to accelerate the deployment of Caterpillar's first battery-electric haul trucks. These machines will soon be operating at our customers' sites where they will be tested and validated across a variety of applications."

SHOWCASING MINING TECHNOLOGY

From fleet management to fully autonomous machine operation, Cat MineStar™ technology has helped transform the mining industry. Caterpillar provides building block technology packages that are scalable to meet the mining operation's needs as it moves along the technology integration journey. Special conversation stations are set up to allow visitors to engage with technology experts and view demonstrations of solutions for surface and underground operations

Every piece of equipment on the show floor will be infused with various levels of technology. In addition to the ultra-class 798 AC featuring Command for hauling, the R2900 XE LHD will be equipped with Cat MineStar Command for underground, which enables remote machine operation. The diesel-electric LHD will also feature MineStar solutions that safeguard against unintended interactions between personnel and assets and enhance operator alertness, both enhancing operating safety.

Optional onboard technologies available for the Cat 995 Wheel Loader include Payload Overload Prevention, Operator Assist and Operator Coaching.

Caterpillar is set to launch two new technology offerings to the MineStar ecosystem at the show:

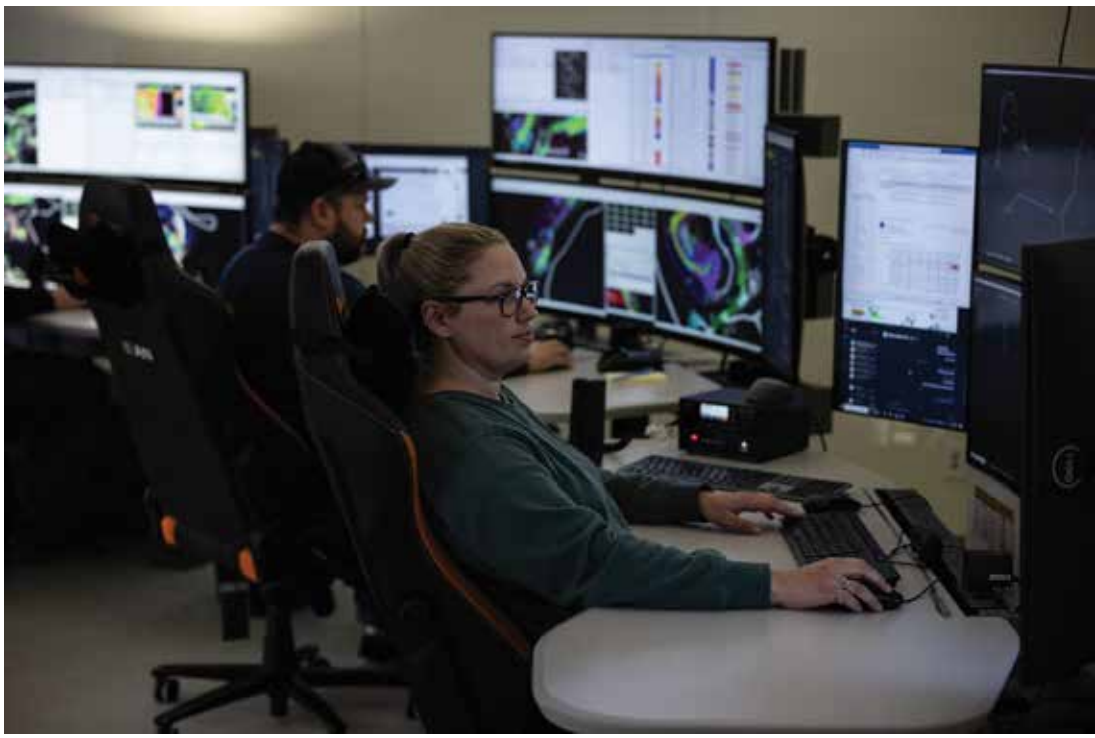
- Delivering the next layer of safety, the Collision Awareness System (CAS) is a site-wide solution that uses the latest in technology advancements to enhance situational awareness by warning operators of potential machine interactions before they have a chance to happen. CAS will be highlighted on the 995 and 798.

- A new office application for Payload Management expands the payload tracking technology to Cat Electric Rope Shovels and Draglines.

Showcasing the capabilities of MineStar Command technology, two remote operating stations will give visitors the chance to operate a dozer or rotary blasthole drill located hundreds of miles away from the Caterpillar exhibit. A third station will offer simulations of Cat Command for underground, demonstrating the technology's versatility and ease of use.

Virtual reality experiences will allow attendees to experience the Cat 7495 Electric Rope Shovel and 6060 Hydraulic Mining Shovel.

"Customers will experience our latest technology innovations and autonomous developments throughout the



Caterpillar show floor at MINExpo," says Sean McGinnis, vice president and general manager of technology and global sales support for Caterpillar. "Mine site automation makes significant impacts in operations and not just with autonomous haulage. Today, we have customers around the world utilizing our autonomous solutions for drilling, loading, dozing, hauling and underground, and we are working with many customers to develop the autonomous sites of tomorrow."

CATERPILLAR DEMONSTRATES NEW AUTOMATED ENERGY TRANSFER SOLUTION FOR BATTERY ELECTRIC LARGE MINING TRUCKS

Caterpillar Inc. is reinforcing its commitment to deliver product design choices in alignment with customers' operational, sustainability and productivity goals that increase the value of a machine throughout its lifetime. These designs align with Caterpillar's strategy to deliver integrated site solutions to support customers today and through the energy transition.

As the industry looks to the future, Caterpillar is purposefully designing a modular Cat® 793 large mining truck platform with powertrain flexibility. This platform will include diesel mechanical, diesel electric and battery electric options.

Additionally, Caterpillar is leveraging the knowledge and validation acquired through its Early Learner battery electric large mining truck program to drive common platform benefits for its ultra class trucks, including diesel electric and battery electric offerings for the Cat 794, 796 and 798 models.

Caterpillar has a legacy of designing products with customers' current and future needs in mind. For decades, Caterpillar and the Cat dealer network have provided flexible solutions to extend the life of mining trucks, including retrofit kits, update and upgrade programs and full machine rebuilds. These options can extend a customer's equipment to align with current products and technologies while reducing total cost of ownership.

Caterpillar Group President Denise Johnson says, "No matter the powertrain you desire, we will have a solution. Designing and supporting machine platforms that drive commonality, modularity and a seamless experience across our product lines is not new to us. Our large mining trucks are engineered to integrate with the technologies of today and of the future."

All current diesel electric and battery electric large mining truck platforms are also compatible with the recently announced Cat Dynamic Energy Transfer system, providing immediate benefit to mine sites that want to lower their operating costs and greenhouse gas emissions while providing flexibility for the future.

Caterpillar Senior Vice President Greg Hepler said, "Caterpillar recognizes every mine site requires a unique plan to meet their sustainability objectives, which is why we are delivering a suite of integrated energy transition solutions, including machines with powertrain flexibility, energy transfer systems, energy storage and management capabilities, autonomy and fleet management systems. Together with our Cat dealers, we are committed to

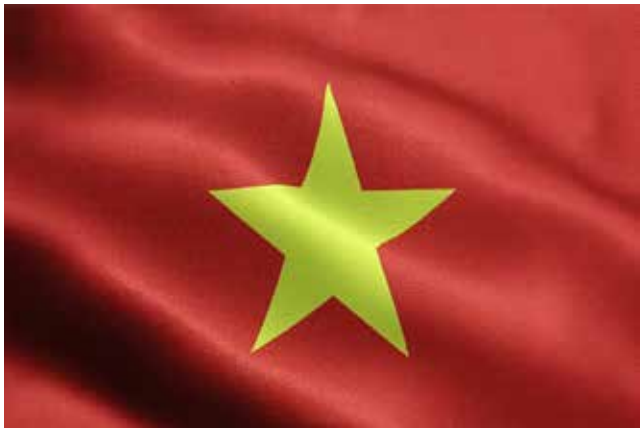
supporting customers through every step of their energy transition journeys."

Caterpillar showcased a new solution to support battery electric truck charging – the Cat® Automated Energy Transfer System (Cat AETS). The company successfully demonstrated this new technology for customers at its Tucson Proving Ground in Green Valley, Arizona.

Cat AETS utilizes robotics, robust vision systems and controls to fully automate the connection between a battery electric machine and a two- to six-megawatt stationary charger. The system replaces the manual process of mine site personnel connecting and disconnecting a charger from a battery electric machine.

Cat AETS enhances mine site safety by removing site personnel directly from the machine charging process, facilitating a more fully autonomous site operation. Automating the charging process can also reduce downtime and improve consistency and reliability of the machine charging process.

Caterpillar Senior Vice President Greg Hepler explains, "When it comes to meeting production goals, every second matters on our customers' mine sites. Through our advancements in mining technology and automation, our repeatable processes enhance machine reliability and ultimately reduce downtime. Caterpillar is proud to offer the solutions that create benefits for the battery electric machine charging process."



Just Energy Transition Partnerships and the future of coal

Recent climate diplomacy efforts have resulted in Just Energy Transition Partnerships (JETPs) with South Africa, Indonesia, and Vietnam, mobilizing financial support for ambitious decarbonization targets. Here, to assess JETPs' alignment with global climate targets, we conduct a model-based assessment of JETPs' energy and emissions targets. Results show greater alignment with a global 1.5 °C trajectory, indicating a promising route for international collaboration to keep Paris Agreement goals within reach.

Just Energy Transition Partnerships (JETPs) are a novel cooperation format to accelerate the energy transition of developing and emerging economies. JETPs bundle financial support from high-income countries into high-level cooperation agreements to facilitate the achievement of energy and climate targets of recipient countries.

The first JETP, between South Africa and the International Partners Group (France, Germany, United Kingdom, USA and the European Union (EU)), was established during COP26[1]. It committed the mobilization of US$8.5 billion to accelerate South Africa's decarbonization, in line with its most ambitious nationally determined contribution (NDC) target. In the wake of COP27, Indonesia, Vietnam and Senegal followed suit in establishing JETPs with the International Partners Group[2,3,4] (expanded to include all G7 members, the EU, Denmark and Norway), agreeing on initial financial support volumes of US$20, 15.5 and 2.5 billion, respectively, towards power sector-related energy and climate targets. With a combined volume of US$45 billion over a 3-5-year period[5], JETPs represent a substantial mobilization of climate finance from developed to developing countries and a step forward to the target of US$100 billion per year defined within the Paris Agreement (Extended Data Figure 1 and Supplementary Section 2).

Despite the urgency to phase out the use of coal for electricity generation to meet the Paris Agreement goals, international climate diplomacy has previously failed to restrain the persistent global expansion of coal-fired power plants[6,7] as a means to cover a growing electricity demand in emerging economies[8]. The unprecedented pace in reduction of coal use[9] implied by the Paris Agreement targets represents a particular challenge for emerging economies[10], straining their institutional capacity[11,12] and raising questions on its

feasibility[12,13]. Against this background, JETPs represent a promising format, yet their alignment with global climate targets remains unassessed.

ALIGNING PARTNERSHIPS WITH PARIS

To assess the 1.5 °C compatibility of JETPs' decarbonization targets, we quantify three policy pathways with the POLES-JRC global energy model for South Africa, Indonesia and Vietnam, as large coal-reliant economies: a reference (REF) under policies and plans before JETP agreements, a JETP energy and emissions target scenario, and a 1.5 °C globally cost-efficient scenario Per construction, the JETP scenario is determined by the JETP targets until 2030. Despite its long-term nature, achieving a global 1.5 °C target will require embarking in a global emissions trajectory with concrete and immediate implications for sectoral emissions, including the power sector composition and emissions by 2030[14]. Depending on emission sources and mitigation options, among other considerations, country-specific 1.5 °C-compatible emission trajectories differ, raising the question on how 2030 JETP targets align with 1.5 °C pathways.

The results reveal diverging evolutions for the capacity of coal-fired electricity generation in the reference scenario in the three countries (**Figure 1b**). South Africa's ageing coal fleet, combined with the policy framework of the Integrated Resource Plan and considerable renewable energy

a	Power dector targets by 2030			
Country	**Coal GW installed capacity**	**Renewables % in power generation**	**GHG emissions $MtCO_2e$**	**Initial financial support volumes over 3-5 years**
South Africa	Not specified	Not specified	Support the achievement of mosg ambitious NDC target[a]	US$8.5 billion[c]
Indonesia	No new coal beyond current plans[b]	>34%	290	US$20 billion[c]
Vietnam	30 GW peak coal capacity, no new coal beyond	>47%[d]	170	US$15.5 billion[c]

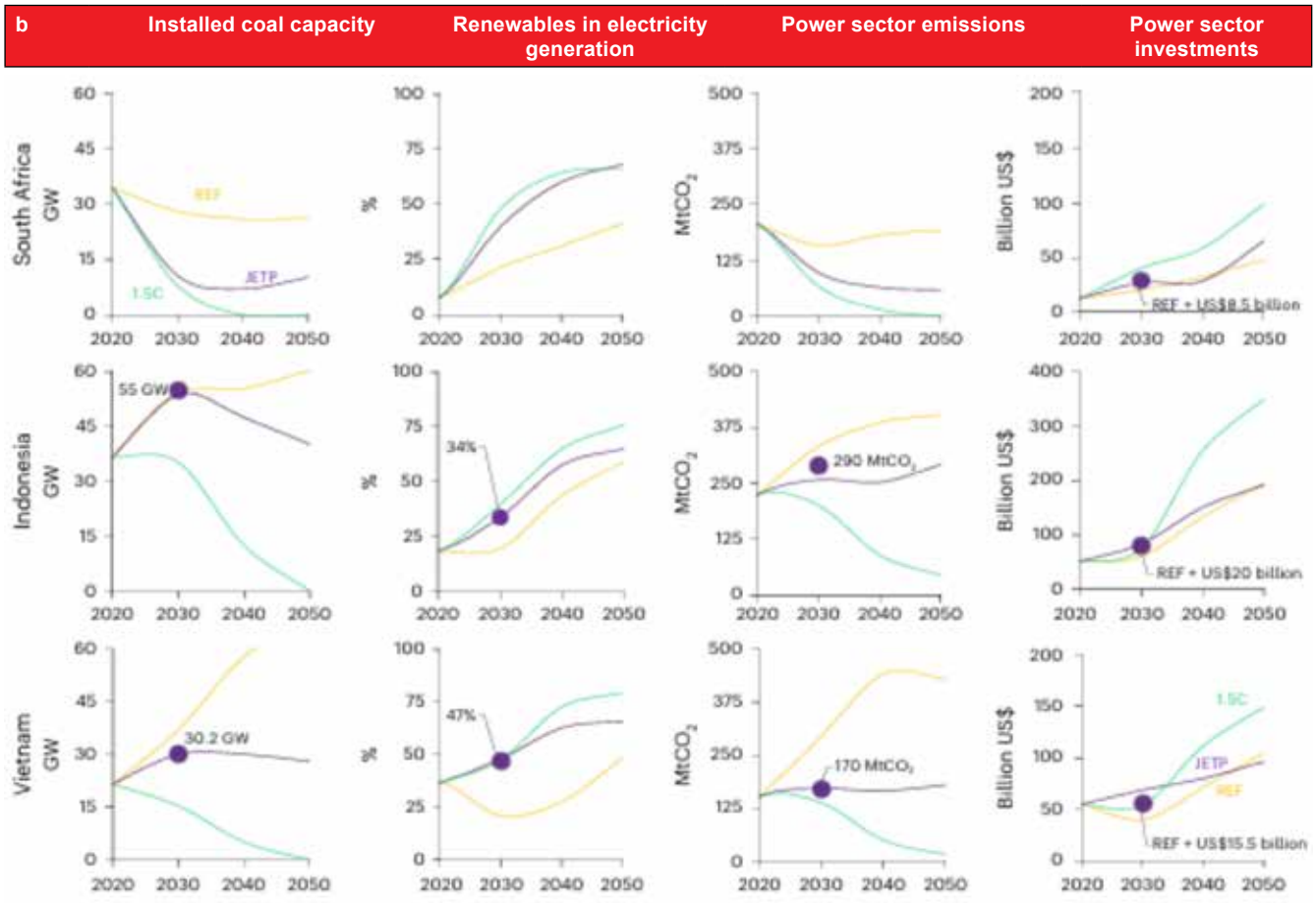


Figure 1: Quantittive JETP targets and power dector indicors across scenarios for South Africa, Indonesia and Vietnam **a:** Summary of key targets in JETPs based on refs. 1-3. **b:** Scenario results for key power sector indicators over time. The dots indicate JETP targets. JETP financial support volumes are contextualized in their totality against power generation investments. Energy and emissions targets determine scenarios (Supplementary Table 4), and investments represent the model outputs, disregarding the funding source. Power sector investments represent cumulative investments in electricity generation capacity over a 5-year period, portrayed as a 10-year moving average. [a]350 Mt CO_2 equivalents (CO_2e) economy-wide emissions by 2030 (most ambitious NDC target). [b]Corresponding to approximately 55 GW by 2030[30]. [c]50%-50% public–private finance. [d]Wind, solar and hydro.

potentials, implies gradually declining installed coal capacity. In contrast, stronger electricity demand growth in rapidly growing economies of Vietnam and Indonesia, younger power plant fleets (Supplementary Figure 2) and political drivers[15] lead to strong planned expansion of coal capacities. Given the tight carbon budget, our 1.5 °C trajectory leaves no room for unabated coal capacity additions (Extended Data Table 1). The particularly steep reduction required in South Africa calls for dedicated efforts in limiting the adverse social implications of such a rapid transition, for example, by investment in revitalizing coal regions, workforce reskilling and economic diversification[11]. Indonesia's and Vietnam's envisioned coal capacity expansions until 2030 within the JETP targets deviate from a globally cost-efficient 1.5 °C pathway. At the same time, the reduction in coal use, even in the 1.5 °C trajectory, is less pronounced than in South Africa, with comparatively less severe socio-political challenges from their respective coal transitions.

In the reference scenario, the share of renewable electricity generation across the three examined countries would fall substantially short of required levels for a 1.5 °C trajectory, but the JETP targets bring considerable alignment with the 1.5 °C trajectory by 2030. The combination of no new coal commitments beyond 2030 with the improving competitiveness of renewable technologies lead to a continued integration of renewable energy towards mid-century. Even in the absence of additional climate policies beyond 2030, the share of renewable electricity generation in the JETP scenario would increase to about 65% in all studied countries, while still falling short by approximately 10 percentage points of 1.5 °C compatible levels in Indonesia and Vietnam.

Limiting coal capacity expansion combined with a higher share of renewable electricity in the JETP scenario leads to a clear reduction of CO_2 emissions over the considered time limit, compared with the reference. Power sector emissions in South Africa under the JETP would strongly decline towards 2030. For Indonesia, the analysis suggests that the JETP emissions target is not binding due to the renewable energy targets in place, which would halve the 2030 power sector emissions gap between the reference and a 1.5 °C pathway. Given Indonesia's envisioned coal capacity expansion until 2030, achievement of its JETP renewable generation target will imply a low utilization rate for those capacities, indicating an economically inefficient capacity expansion planning. For Vietnam, the 170 $MtCO_2$ power sector emissions target in 2030 closes about 80% of the 2030 power sector emissions gap between the reference and a 1.5 °C scenario. While 2030 JETP emission targets improve alignment with a 1.5 °C target, they still fall short of 1.5 °C compatible levels for all three countries in terms of power sector emissions. Pursuing mid-century net-zero decarbonization pledges remains essential to comply with the goals of the Paris Agreement.

In the absence of JETP targets and financial support, near-term investment for the expansion and technological overhaul of the power sector reaches close to US$50 billion in Indonesia and Vietnam (each) and US$12.5 billion in South Africa, according to our estimates (over a 5-year period; **Figure 1**). JETPs support additional investment

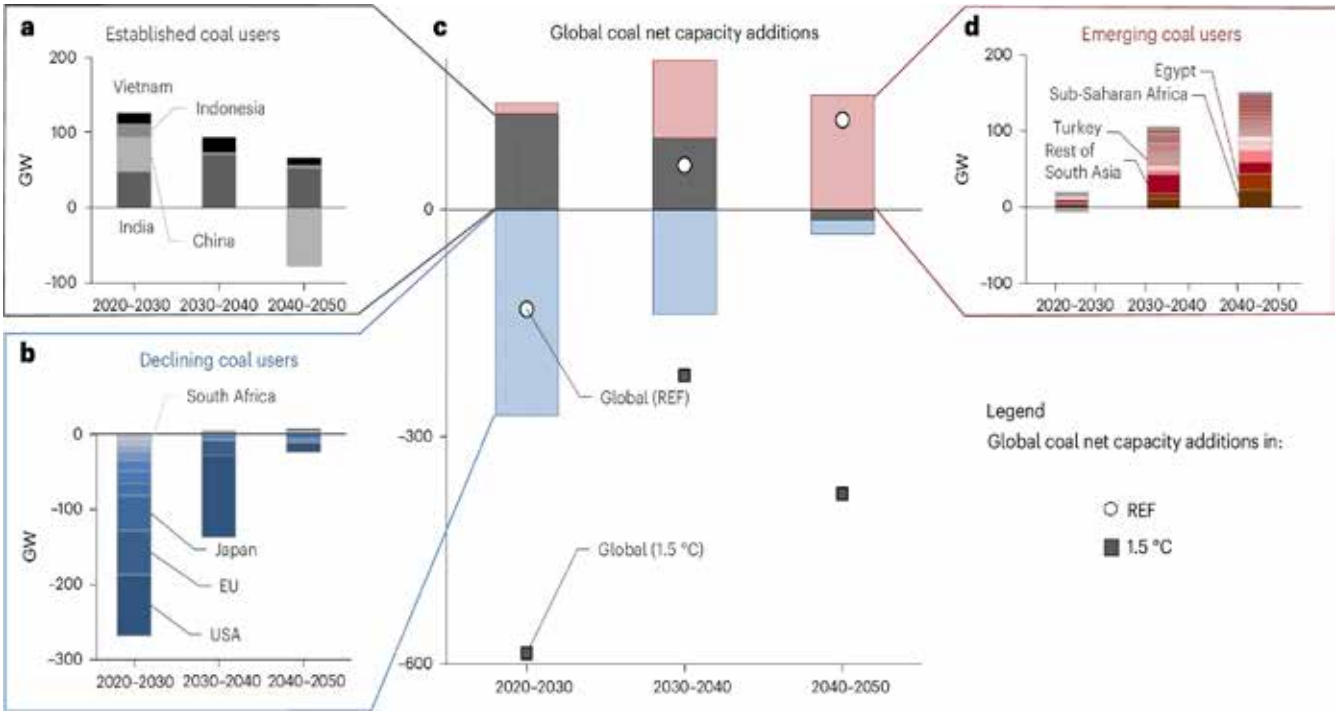


Figure 2: Global net coal power capacity expansion by expansion pattern groups. The bars reflect the reference scenario, and the markers show global net additions in both the reference and 1.5 °C scenarios. **a:** Established coal users with substantial short-term net coal capacity additions. b, Users with declining coal capacities. **c:** Global aggregate of coal net capacity additions by country group (REF) and total (REF and 1.5 °C; see Methods for scenario clarification). **d:** Countries and regions with potential future net coal capacity expansions under reference policies. See Supplementary Section 1 for additional details on country categorization and Supplementary Tables 1 and 2 for the underlying data.

driven by JETP energy and emission targets. Our results indicate that the initial financial support foreseen in the JETPs fully cover these additional investments in South Africa and Indonesia, and roughly half of the investment needs in Vietnam. In Vietnam and Indonesia, however, investments in the JETP trajectory surpass the levels implied by the 1.5 °C scenario in 2030, given the short-term expansion of both renewable and partly unnecessary coal capacities. These coal capacity additions bear a risk of becoming stranded assets. To support larger investment flows of a 1.5 °C trajectory, JETPs are designed as catalytic mechanisms, aiming to improve conditions for private investment in renewable energy. JETPs support a structural and political risk reduction[16], developing dedicated regulatory reform roadmaps for clean investments. The extent to which grants and concessional public finance foster learning[17] in the financial and energy sectors will largely impact on the private financial flows and costs for the transition, given the capital intensity and risk sensitivity of renewable technologies to financing conditions[18].

Achieving a 1.5 °C-compatible trajectory will require scaling up initial JETP goals' ambition. Beyond its own emissions, the power sector decarbonization represents a fundamental step to decarbonizing the whole energy system via electrification of end uses[6,19,20]. Scaling up energy efficiency investments, keeping captive coal capacities in check and transforming coal-intensive industries (for example, steel manufacturing) will be important elements to align with a Paris trajectory. Corresponding targets, backed up by implemented policies, could complement existing or new JETPs. As such, initial JETPs' energy and climate goals offer an entry point to more ambitious climate policy packages, in line with the scientific literature demonstrating how stringent climate policy regimes can be implemented by incrementally increasing ambition[21,22,23].

JETPS COVERAGE AND THE EMERGENCE OF COAL-RELIANT ECONOMIES

Despite the global surge in renewable electricity (Supplementary Tables 1 and 2), phasing out coal use in line with the Paris Agreement goals (Extended Data Table 1) will require dedicated policy support[24]. Rolling out JETPs to further coal-reliant economies can represent a step towards keeping the Paris Agreement goals within reach. Geopolitical considerations aside, addressing large and growing coal-reliant economies bears strong potential to reduce global emissions. China and India, each accounting for about 30% of net coal-capacity additions in 2020-2030, and home to approximately 55% and 10% of global installed coal capacities, respectively, are of utmost importance in limiting short-term global coal expansion patterns (**Figure 2**). Beyond 2030, potential emerging coal users (**Figure 2d**), inter-alia South Asian and Sub-Saharan growing economies, could potentially contribute to global coal emissions. Timely anticipation, for example, as envisioned in Senegal's JETP, can help avoiding a potential coal phase-in rather than managing a coal phase-out. Continued climate policy and diplomacy efforts to prevent coal expansion via varied mechanisms will remain important, for example, leveraging trade policy[25] or international finance regulating frameworks (for example, via taxonomies). Jointly, such mechanisms can support existing JETPs and prevent the emergence of new coal-dependent economies, while averting misaligned incentives to sustain low domestic climate ambition in the expectation of international finance.

The scientific community can support international discussions by providing up-to-date pathway analysis, with fine-grained country resolution accounting for local conditions[26,27], while considering equity through, among others, transfers and effort sharing[28]. Multi-model studies[29] can present a robust range of 1.5 °C indicators (Extended Data **Table 1**), offering political leeway for reaching meaningful international agreements. Amidst the rise of industrial policy and protectionism, long-term partnerships represent a promising format to sustain cooperation in global challenges such as climate change. Cooperation beyond the provision of financial support can help in addressing prevalent technical, institutional, and social challenges, and international fora can provide a useful platform for knowledge-sharing from policy design to its implementation stage. As domestic policies are incrementally aligned with JETPs' targets and impacts become measurable, the scientific community should critically assess successful elements and shortcomings of this novel cooperation format to inform global efforts to mitigate climate change in a just and equitable manner.

METHODS

To contextualize JETPs within global prospective coal expansion projections and assess their 1.5 °C compatibility, we use the POLES-JRC global energy system model. POLES-JRC is a global simulation model of the energy sector, with complete modelling from upstream production through to final user demand. It follows a year-by-year recursive modelling, with endogenous international energy prices and lagged adjustments of supply and demand by region (partial equilibrium), which allows for describing full development pathways of energy and emissions to 2050. Macroeconomic projections of gross domestic product and populations are taken as exogenous inputs. The model provides full energy and emissions balances for 66 countries or regions (including an explicit representation of South Africa, Indonesia, and Vietnam), 14 fuel supply branches and 15 final demand sectors. This analysis used the POLES-JRC version of Global Energy and Climate Outlook (GECO 2022[30] as a starting point, which included recent (year-2 to same-year) data statistics on energy demand, capacities, and prices. A comprehensive description of the model is provided in the model documentation[31]. As a consequence of model mechanics and differing input assumptions, scenarios may differ from alternative energy and emissions projections, for example, from official national sources and international organizations.

We consider three scenarios, with varying targets and policies impacting on the energy system development.

1. Reference: corresponding to a scenario where energy supply and demand and climate policies and targets before JETP agreements are enacted in JETP countries. The rest of the world follows energy and climate policies adopted as of June 2022. Electricity capacity expansion in JETP countries is calibrated according to power

development plans before the establishment of JETP targets. The resulting share of renewable electricity generation, power sector emissions and necessary investments represent model outputs.

2. JETP: building on the reference, this scenario considers the 2030 JETP targets shown in **Figure 1**, but no additional targets or policies (for example, long-term decarbonization pledges). For South Africa, lacking specific JETP power sector targets, all elements shown in **Figure 1** represent model outputs, following a least-cost rationale to achieve the country's economy-wide, 2030 emission target (implemented by use of an economy-wide carbon price; For Vietnam and Indonesia, investments and emissions shown in **Figure 1** represent a model output.

3. 1.5 °C: this scenario is designed to limit global temperature increase to 1.5 °C. The scenario features a global carbon budget over 2020-2100 (cumulated net CO_2 emissions) of approximately 400 $GtCO_2$, resulting in a 50% probability of not exceeding the 1.5 °C temperature limit in 2100, with an overshoot to 1.7 °C in 2050 (falling in the category C2, below 1.5 °C with high overshoot, of the Intergovernmental Panel on Climate Change AR6 WGIII; temperature levels and probabilities were obtained by the online MAGICC tool). A single global carbon price for all regions is used in this scenario, starting immediately (2022), and strongly increasing. Bottom-up policy drivers (such as capacity targets) from the REF or JETP scenario are not included here, and all elements shown in **Figure 1** are computed endogenously. This scenario is therefore a stylized representation of an economically efficient pathway to the temperature target, as the uniform global carbon price ensures that emissions are reduced where abatement costs are lowest. Its trajectory to net-zero emissions has concrete implications for sectoral and temporal levels of emissions, offering a comparison point against the 2030 JETP targets.

Online content: Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code avail ability are available at https://doi.org/10.1038/s41558-024-02086-z. References 1. 2. 3. Political declaration on the just energy transition in South Africa. European Commission https://ec.europa.eu/commission/ press corner/detail/en/ip_21_5768 (2021).

For further and detailed references please use the following link: Just Energy Transition Partnerships and the future of coal | Nature Climate Change

NEWS, PLANT AND EQUIPMENT

Anglo American bidders down to three, say sources

The final bidders for Anglo American's Australian coal assets are down to Yancoal Australia, Stanmore Resources and Peabody Energy Corp.

Yancoal, Peabody and Anglo American declined to comment on the bidding process. Stanmore did not immediately reply to a request for comment.

Anglo is acting on a plan to restructure its business by selling and divesting unwanted assets after fighting off a $49-billion takeover bid from larger rival BHP Group in May.

That has kicked off with the sale of its portfolio of five steelmaking coal assets in Australia – Moranbah North, Grosvenor, Capcoal, Dawson and Jellinbah.

Anglo last week agreed to sell a 33.3% stake in a joint venture that owns a 70% interest in the Jellinbah East and Lake Vermont steelmaking coal mines for A$1.6-billion ($1.04-billion).

The sales would end Anglo's active mining operations in Australia but it will continue exploration activities in the country.

The sales process is expected to conclude by the end of the month, when a freeze on BHP making an approach for Anglo set down by the UK takeovers legislation expires.

Analysts at Jefferies estimated the value of the five assets at $4.5-billion before a fire at its Grosvenor mine earlier this year.

Tradelink Publications Ltd

Publishing and Website Services for the Mining Industry

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

Connecting with our audience – Best of both worlds

Putting our customers first

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

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

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

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

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

MINING & QUARRY WORLD

COAL INTERNATIONAL