The future is now

Mining companies need to put aside any uncertainties and start reducing carbon emissions today

By Kelsey Rolfe

When Generation Mining's Marathon palladium project in northern Ontario is finally built, it will have a smaller site footprint than initially envisioned. The company redesigned its mine plan to include a satellite crusher in the open pit and tailings-storage haulage roads as close to the pit as possible to reduce cycle times. It also included some downhill hauling with in-pit waste storage.

"Some of these things are smart engineering and the right thing to do, but they add the benefit of minimizing your diesel burn and your GHGs [greenhouse gas emissions]," said chief operating officer Drew Anwyll.

Generation Mining also plans to introduce other site optimizations, such as Woodgrove Technologies' direct flotation reactors at its copper and platinum group mineral (PGM) flotation plant, which will improve the concentrate grade while drawing less power from the Ontario electricity grid. The goal of these changes is to chip away at the site's future GHG emissions as much as possible, in line with a net-zero future.

Like other mining companies – many of whom have made public pledges to reach net-zero GHG emissions by dates like 2050, including International Council on Mining and Metals (ICMM) members, or 2040 (such as Anglo American) or even 2030 (which is when Fortescue Metals intends to be carbon neutral in Scope 1 and 2 emissions, with Scope 3 following by 2040) – Generation Mining knows that running the cleanest mining operation possible has become a necessity, both from an environmental as well as a business point of view.

Currently, the mining industry represents between four and seven per cent of global GHG emissions and two to three per cent of global carbon dioxide emissions, according to McKinsey & Company, so reducing those numbers will go a long way in halting climate change.

The catch, however, is that since nobody has done this before, nobody knows exactly what they are facing or precisely how to achieve all their goals.

Costly risks ahead

Reaching net zero will require difficult and costly work, made up of major changes and smaller optimization projects, and will require miners to get comfortable with making bets on technology that is not yet commercialized or even piloted. They will also have to get creative when deploying existing technology in new ways or environments.

At Generation, for example, Anwyll said the company has its eye on larger step changes. The company is in conversations with original equipment manufacturers for the consideration of trolley assist for Marathon's steepest incline, which would also be the trucks' largest diesel draw. The company has also been

discussing battery-powered vehicles as well as those powered by hydrogen fuel cells. But, according to Anwyll, there are a lot of factors to consider before signing the purchase order.

"For trolley assist, there's a lot more electrical infrastructure you have to put in and the cost of the equipment is slightly higher," he said. "What we're talking with the OEMs and trying to be creative with them about – and they're pretty receptive, to be honest – is how we can have a project that... starts with a certain fleet and how we can change it out at mid-life without having to buy a new fleet. Those challenges genuinely exist."

Planning for changes and implementing upgrades tends to increase the cost of doing business.

While the price varies, McKinsey estimated an average 25-million tonne run-of-mine facility that aimed to reach net zero between 2030 and 2040 would incur between US$100 million and US$130 million in transition costs.

"We as an industry have to be willing to take on a bit of that risk, and we have to have the right culture," said Brian Mashford, mining, minerals and metals business leader at Stantec. "The risk can be managed, but we have to be able to move that forward."

Building the road

For all the companies that have released ambitious targets in the past year or two, Mashford said many are still figuring out the path to meet them. "What the industry is faced with right now is having great targets to achieve, but not well-defined plans. They understand they have to get there but don't know how to, and that's where we're helping clients right now."

Theo Yameogo, mining and metals leader at EY, said a significant part of those plans is ensuring miners have the "right talent, systems and technology" to achieve their goals, including hiring for new expertise and having rigorous, third-party validated data on site emissions.

For Yamana Gold, its planning work revealed good news. The company started 2021 by announcing it would bring its GHG emissions in line with the Paris Agreement's standard two-degree-Celsius warming scenario by 2030 and set an aspirational target of net zero by 2050. By December, Yamana significantly upped its ambition, releasing GHG abatement targets that promised to meet the 1.5-degree Celsius increase limit compared to pre-industrial levels and committed to annual emissions reductions of 4.2 per cent until 2030. The change was a result of evaluating its baseline emissions and testing out three scenarios – two degrees Celsius, well below two degrees Celsius, and 1.5 degrees Celsius.

Craig Ford, Yamana's senior vice-president of health, safety and sustainable development, said the company's emissions forecast indicate it will not cross the 1.5 degree Celsius curve until the end of 2025, meaning "we've got a little bit of time to...understand the cost better, and the opportunities." The company has a "preliminary view" of the "modest" investments it expects to make, ranging from battery electric vehicle (BEV) technology and renewable-power purchases to energy-efficiency projects.

"Until we went through [the planning and analysis efforts], we didn't know how things were really going to work," Ford said. "I'm really pleased with where we are and what the future

holds for our ability to meet what, at the beginning of 2021, we thought was an ambitious target."

Plugging in

Each mine will face site-specific requirements – such as heating at northern mines, smelters with natural gas- or propane-fired dryers, ventilation for underground operations and fugitive methane emissions at coal mines – but all operations have two major GHG sources in common: nonrenewable power and diesel-powered haul fleets. A June 2021 report from McKinsey estimated between 40 and 50 per cent of the sector's CO2 emissions come from equipment diesel use, and another 30 to 35 per cent from nonrenewable electricity sources.

Emily Thorn Corthay, founder and CEO at Thorn Associates, an energy and carbon management consulting firm, noted companies with operations in jurisdictions that have close to zero-carbon grids, or access to power purchase agreements (PPAs) with independent producers, already have a leg up. Off-grid, ultra-remote mines, particularly in the North, will face a much bumpier road to decarbonizing. Wind power is possible, and small modular reactors hold promise but are not yet commercially available.

Yamana has renewable grid power at its Wasamac project in Quebec, and has PPAs for its Minera Florida, Jacobina and El Peñon operations; about 85 per cent of the company's gold equivalent ounces will be produced with renewable energy by the end of 2022. The company's Cerro Moro gold and silver mine in southern Argentina represents its largest unrenewable power challenge: the site is entirely diesel-powered due to its remote location. In 2022 the company will evaluate the possibility of connecting Cerro Moro to the country's grid or establishing a wind project at the site.

Ford said he saw decarbonizing the site's power as "one of several compelling options" for the company to meet and exceed its 2030 goals.

But even in provinces or countries with plentiful renewable power, miners could soon face stiff competition for grid access as other industries make their own net-zero transitions. According to a December report from Clean Energy Canada (CEC) at Simon Fraser University, Canada will need twice as much clean energy by 2050 to fully decarbonize the economy.

In the short term, the country will need to clean up existing fossil-fuel sources through carbon capture and storage or bring new projects online to replace them entirely, said Mark Zacharias, the report's author and a special advisor at CEC. In the long term, "there will be enormous need for net new electricity generation that's non-emitting" to accommodate new and expanded grid users. ("Net new" refers to building enough capacity not just to replace fossil-fuel powered generating stations, but to add to the overall available power.)

Charging up

Nowhere is the promise and risk of new technologies more evident than in no-carbon fleets. While BEV use has grown significantly in underground operations, large battery- or hydrogen fuel cell-powered haul trucks for open-pit mines are still in the pilot stage. BEVs for all operations typically require additional infrastructure expenses and changes to mine design, in addition to higher upfront vehicle costs.

"It's a bit of a challenge right now," Ford said. Yamana is looking at incorporating BEVs at in-development operations such as Wasamac and Odyssey. "It's not commercialized to a degree we want to see. But it's coming."

Mining companies are increasingly partnering with suppliers to test new equipment in their operations to ensure the technology is mine-ready within the next 10 years, Mashford said.

But the fleet calculation is particularly difficult for junior companies. "[Majors] have the ability to look at slightly longer payback periods than a junior does, than a company like Generation has," Anwyll said. "It really challenges the commitment to getting to zero. We have to be a bit more creative and focused on it."

For companies that can't yet commit to BEVs, biodiesel is a "good stepping stone in the journey that can get you a decent part of the way," said Thorn Corthay. However, the fuel, which is made out of canola oil, recycled oils, animal fats, and soybean oil, can gel up in winter weather.

The upfront risks of new vehicle technology are expected to more than pay off. By 2030, the total cost of ownership for a battery or fuel cell electric 400-tonne haulage truck is expected to be 20 per cent lower than diesel-powered, due to lower maintenance costs and fuel costs, McKinsey's June report said. Switching to sustainable fuels, meanwhile, will increase total cost of ownership by 10 to 15 per cent today and approximately five per cent by 2040, according to the report.

Beyond the mine

While miners can make significant strides with site-level changes, Yameogo pointed out that Scope 3 emissions will represent the biggest hurdle, making up 28 per cent or more, depending on the estimates, of the sector's total GHG emissions. "You need to think about the carbon footprint of explosives before you use them, you need to think about contractors coming to the site – are they driving, taking a plane, what's the carbon footprint?" he said. "It's harder to know what your suppliers are doing."

The ICMM member companies, in an October open letter, called on suppliers to help decarbonize their supply chains and commit to releasing Scope 3 goals by the end of 2023 or "as soon as possible."

Despite the challenges, Mashford said the industry is well-positioned to meet its short- and long-term goals. Miners have been driving down energy usage for years through ventilation on demand, heat recovery systems and other technologies.

But the time for timidity has long since passed, Thorn Corthay said.

"Some clients are afraid to commit or make the leap, and there's also a very large learning curve and they can sometimes be overwhelmed," she said. "As soon as you have your bottom-up, site-by-site GHG opportunities identified and costed, then go for it. Having the ambition to commit to ambitious targets is critical. Mining companies will not have the licence to operate if they do not become more ambitious, but those who rapidly decarbonize will reap the benefits." CIM

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Courtesy of Eldorado Gold

Adding a high-pressure grinding roll and removing a tertiary crusher not only extended Kışladağ's life of mine and improved recovery rates, it is saving Eldorado Gold energy as well, lowering the company's carbon footprint.

The mineral processing footprint

Miners are being challenged to improve processing energy efficiency on all possible fronts

By Kelsey Rolfe

In July 2021, Eldorado Gold replaced the tertiary crushing circuit with a Weir Minerals Enduron high-pressure grinding roll (HPGR) at its Kışladağ gold mine in Turkey, a move that the company said would contribute to extending its "cornerstone" asset's life to 15 years.

According to the company's updated NI 43-101 on Kışladağ, a high-tonnage heap-leach gold operation, HPGR test-work yielded an average increased recovery of 3.9 percentage points at the highest operating pressure, reaching 54.8 per cent gold recovery in comparison to the base test of 50.9 per cent. The machine, which replaced five tertiary cone crushers, allowed Eldorado to increase its throughput rate to 12.6 million tonnes per year, up from 12 million.

The change-up also had an additional benefit, said Simon Hille, Eldorado's senior vice-president of technical services: the HGPR is significantly more energy efficient than the previous crushing stage.

"Much more of the energy goes towards breaking the particle," he said. "So we are looking at using this energy to unlock pathways for metal extraction. It's certainly very key for high-tonnage heap-leach operations."

Energy efficiency has taken on new importance in light of the company's commitment to significantly reduce its carbon footprint. Eldorado said in February 2022 it would slash its greenhouse gas emissions by 30 per cent from 2020 levels by 2030, or approximately 65,000 tonnes of carbon dioxide equivalent. Hille noted that Kışladağ, along with Eldorado's other assets in Turkey and Greece, are connected to "brown" grids powered by a large percentage of fossil fuels.

Mineral processing accounts for between three and six per cent of the world's electricity consumption. At the site level, comminution represents 36 per cent of miners' total energy usage, and flotation, filtering and drying makes up another four per cent, according to a 2021 report commissioned by Weir Group and written by Engeco, an Australia-based energy and climate change strategy consultancy. (Diesel use makes up the remaining 60 per cent.) The grinding mill is typically the single largest user of mine site energy, the report found.

Average processing energy usage by commodity

COPPER

between 32-37% on comminution, 4-14% on other processing (depending on the use of concentrator or leaching)

NICKEL

47% on comminution, 5% on other processing

GOLD

26% on comminution, 14-29% on other processing (depending on open pit or underground)

Magnetite iron ore

43% on comminution, 16% on other processing

— data from 2021 Engeco Pte report

Average CO_2 emissions per tonne of select refined metals

ALUMINUM

(at a global average of 40% aluminum): 15.7 tonnes of CO_2 per tonne of metal

COPPER

(at a global average of 0.62% copper): 4.5 tonnes

ZINC

(in the range of 2-6% zinc): 3.8 tonnes

NICKEL

(global average of 1.6% nickel laterite, and 1-2% nickel sulfide): 32 tonnes

— data from Phillip Mackey's John F. Elliott Lecture

Improving the efficiency of these processes could help miners with non-renewable power sources make significant dents in their carbon footprints.

Grinding down energy use

Making changes to an existing grinding circuit can be challenging, but Marc Allen, founder and technical director of Engeco and author of the 2021 report, said there are numerous ways for mineral processors to reduce the mill's energy draw.

A grinding audit can help ensure that the grinding circuit is optimized for flotation or leaching to prevent against expending unnecessary energy on over- or under-grinding, and maximize throughput. Advanced process controls for the mill can help processors set and maintain an optimum grinding range.

Hille, meanwhile, emphasized the importance of a strong understanding of ore characterization, and making sure there's been an "effective analysis made around the liberation requirements relative to recovery."

He also noted that while mineral processors can push for the ultimate recovery at their plants, a small percentage increase often requires a disproportionate amount of additional grinding and energy use. There is also a risk of over-grinding and making the ore too small and difficult to float, when concentrating through flotation, he said.

Linking grind size and recovery at Eldorado's Lamaque underground gold mine in Quebec helped the company get a larger throughput, of 2,500 tonnes per hour (TPH), out of its process plant for the same energy draw as the nameplate capacity of 1,850 TPH, Hille said. While Lamaque's Triangle deposit already has a relatively consistent ore character, one of the key factors was finding the optimal leach time. Balancing leach time and grind size to find the optimal recovery is an important metallurgical skill and will prevent energy wastage through over-grinding.

Improving blast patterns could also reduce the amount of energy needed during the grinding phase, Allen said. "The more breakage we can do of the rocks before we hit the grinding circuit, the better."

Brownfields versus greenfields

While replacing more inefficient equipment, such as the SAG mill, with newer technology has the potential to save on energy, Allen acknowledged it can be a costly endeavour, and is dependent on whether the ore is amenable.

But, he added, greenfield operations have a major opportunity to "make better energy decisions" and develop a more efficient flow sheet, incorporating equipment like HPGRs, high intensity grinding and stirred or vertical mills.

"Looking at different ways to approach flow-sheet design is key, because once you embed that energy, once the SAG mill is in place, there's not much more you can do to make it more efficient," said Hille.

The processing plant's physical footprint – including the use of concrete and larger buildings with higher ceilings to accommodate large flotation circuits – also represents an opportunity for greenfield operations to reduce emissions, said Glenn Kosick, chief executive officer of Woodgrove Technologies.

Kosick gave the example of a conventional flotation plant with seven cells, which sit on concrete pads, explaining that most conventional flotation cells have a step height between cells of 0.6 metres to one metre. The top of the concrete pedestal for the first cell would be between 4.2 and seven metres high. The diameter of a large tank cell can be between eight metres and 11 metres. Using these dimensions, this means a minimum of 14 to 38 cubic metres of concrete for the first cell pedestal alone. Additionally, other factors such as earthquake proofing and soil conditions can require even larger or thicker pads, and consequently more concrete.

Manufacturing of one cubic yard of concrete generates about 400 pounds of carbon dioxide. The company's staged flotation reactor (SFR) and direct flotation reactor (DFR) have footprints about two-thirds and one-third the size of a conventional plant, respectively, and the DFRs sit flat on the floor.

"That's a big contributor, the construction of these facilities," he said. "If we can reduce that, it's an important thing — as well as the cost [savings]."

In terms of cost savings, Kosick claims a net operating energy savings of between one-third and one-half of conventional flotation cells for SFRs and DFRs respectively.

The geometallurgy opportunity

Allen said geometallurgy – the integration of geological, mining and metallurgical information and practices to improve an ore body's value and minimize technical risks – holds a lot of

potential to reduce energy use from the grinding mill by significantly improving the consistency of ore the processing plant receives. But he said it is not commonly done within the sector.

"There's a tendency to operate geology, metallurgy and mining all as separate silos: geologists know what's in the resource, miners mine whatever's in the mine plan and metallurgists have to deal with it," he said. "Breaking down those barriers... means you don't have a plant that just takes what it's given."

The practice involves dividing the ore body into blocks and developing technical parameters for how amenable each block is to grinding, creating a predictive mineral-processing model and optimizing the flow sheet based on that.

"Ore bodies are highly variable, their characteristics change, so the deeper the understanding one can get of the ore body and the finer resolution and understanding [of] energy requirements throughout the blocks...you're able to optimize the grinding design to minimize the power required," said Kosick, whose previous company, MinnovEX Technologies, specialized in the use of geometallurgy in grinding circuit design.

While geometallurgy has been discussed for years, Allen said it can be done more effectively today thanks to advancements in computing technology and data manipulation capability that allow for higher fidelity block models.

Innovations underway

According to Allen, the industry's conservative approach to technology has slowed the adoption of new energy-saving mineral processing technology.

"The industry is very good at being first to be second...[and] it becomes a little difficult to get this technology at the lab scale and the pilot scale, and convince someone to do it in the field," he said. "There's also this tendency to think, 'this situation works quite well right now,' which feeds into the hesitance to move."

But Hille said he thinks that mentality is changing, with the push towards net zero prompting mining companies to start evaluating the energy footprint of major pieces of equipment upfront.

Numerous research projects are also under way to significantly change the way ore is processed. In 2018, federally funded agency Impact Canada launched the Crush It! Challenge, which aims to find innovative approaches to reducing comminution's energy draw. While the pandemic delayed awarding a winner, six semi-finalists received $800,000 each to prove out their technology.

"That innovation space is thriving right now," said Hille. "A lot of budding technology is coming down the pipeline." CIM

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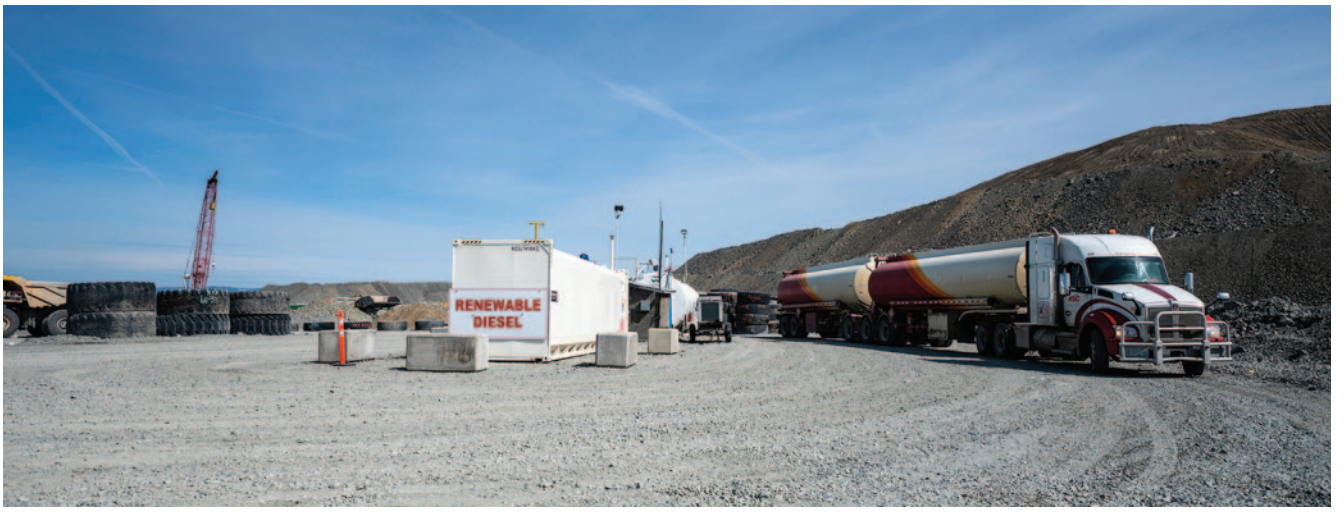
Courtesy of Copper Mountain Mining Corp.



Making efforts to reduce greenhouse gas emissions, such as by using renewable diesel, is important if Copper Mountain Mining Corp. wants to reach net-zero emissions, but the company must also be able to track those emissions, and that is where the blockchain-based Mines Digital Trust comes in.

The carbon picture

Mines are using tools to track emissions, not only for their own benefit but for their customers'

By Kelsey Rolfe

Last fall a made-in-Canada mining-emissions tracking ecosystem made its debut at the United Nations Climate Change Conference (COP26) in Glasgow, Scotland.

In a video presented at the conference, Bruce Ralston, British Columbia energy, mines and low carbon innovation minister, previewed the Mines Digital Trust (MDT) ecosystem, a blockchain-based system that will allow B.C. mining companies to share verified evidence of their environmental, social and governance practices, including their annual greenhouse gas (GHG) emissions, based on provincial data. The ecosystem was developed in partnership with IBM and Copper Mountain Mining Corp.

Don Strickland, Copper Mountain's chief operating officer, said he hopes the ecosystem will evolve to the point where consumers can get "the full story" on a product – from an electric vehicle to a new cell phone – and its GHG emissions intensity when they purchase it.

"If you have the opportunity to buy a vehicle and can scan a barcode and find it has a responsible production credential and say, 'I'm going to buy brand X because it's responsibly produced and I want to support that,' you will drive the people producing metals [to produce more responsibly]," he said.

MDT is just one of a host of emissions-tracking tools being rolled out for the mining sector by consortiums, researchers, governments and technology providers from around the world. While many mining companies track emissions data internally, these technologies are aiming to make the industry's emissions profile more transparent and accessible to the public as well as to present companies with scenario-modelling options for emissions reduction.

Leveraging blockchain

MDT's COP26 appearance was a public, initial proof of concept to demonstrate the open blockchain technology, which involved transferring a digital GHG credential with verified emissions data on Copper Mountain's operation from the provincial government into the company's digital wallet.

Work continues on the blockchain to allow companies to share their emissions data with auditors, suppliers, buyers, investors and other stakeholders and to introduce "checks and balances" that add to its credibility. MDT's creators want to add real-time updating capabilities, meaning if an auditor found a discrepancy in a mine's emissions data, that information could be immediately entered and visible to all blockchain participants.

Mining companies will be able to use a QR code to share carbon emissions data from MDT with the Open Climate network, a blockchain-based global climate accounting system being developed by the Yale Open Innovation Lab, OpenEarth Foundation and others.

Modelling future emissions

Researchers at the University of Queensland's Sustainable Minerals Institute see their Greenhouse Gas Emissions Management Tool (GGEMT) not just tracking mining emissions but also helping companies to map their lifecycle Scope 1 and 2 emissions and to simulate reduction efforts.

GGEMT uses data on production and performance, ore body properties, energy and fuel consumption, and direct and indirect emissions intensity for each production stage to visualize a mine's carbon emissions from mine to market, said Mohsen Yahyaei, an associate professor at the university. Users can simulate a range of scenarios by changing various data points or adding in Scope 1 or 2 reduction initiatives; they can also compare scenarios over a 17-year time horizon.

"The outputs can be used as a guideline to prioritize production stages that have the most impact on GHG reduction and identify [the most effective] mitigation plans," Yahyaei said.

Global research and consulting group Wood Mackenzie's Emissions Benchmarking Tool (EBT) takes a different tack, drawing on a combination of mining and metals companies' public sustainability documents and its own in-house work on many operations to create emissions profiles of mines around the world, spanning a range of commodities.

James Whiteside, Wood Mackenzie's head of corporate for metals and mining, said mining companies are by far the tool's biggest client base. EBT has also been increasingly used by equity researchers, bankers involved in mining transactions, traders and consumers.

EBT allows companies to compare themselves against their peers and find areas to decarbonize. Users can also forecast commodity, company or asset emissions beyond 2030, and even break that forecast down into Scope 1 and 2 emissions.

The forecasts are built from Wood Mackenzie's work costing and valuing assets, Whiteside said, which involves understanding all the various cost components of a site as well as the asset's production stage and mine life. A mature copper operation, for example, might be increasing its strip ratio while its head grade falls, increasing total material movement and energy usage over time. The company then aligns that information with emissions factors for diesel and the site's power source to project emissions forward.

Data challenges

Emissions monitoring and modelling tools across the board each face a common challenge: quality data.

When the Australian researchers began developing GGEMT, it quickly became clear there are many factors that can influence a site's GHG profile and the connections between them are not well understood, Yahyaei said. For instance, "the link between electrification of various stages of mining and the GHG emissions intensity, and incorporating Scope 3 emission reduction solutions into the tool requires research to understand the underlying factors [that] link to GHG emissions and model their interdependencies."

To try to account for those connections, GGEMT uses what is called system dynamic modelling – a type of simulation that hypothesizes and uses connections across processes, to identify dependencies between variables that could affect a site's emissions. But Yahyaei said the tool currently looks at Scope 1 and 2 emissions at a "very high level."

He also noted that due to a lack of sensors for direct measurement of GHGs, companies generally calculate emissions based on estimates, limiting the tool's accuracy. The Sustainable Minerals Institute is currently developing a consortium of mining companies, technology providers and researchers to do further research that could improve GGEMT's capabilities.

Whiteside said Wood Mackenzie also had to think through how to get consistent data because companies' approaches to public sustainability reporting and their level of detail vary significantly. The company reviewed technical papers, footprint analyses and sustainability reports to get the most comprehensive picture.

EBT also calculates GHGs on a carbon-dioxide-equivalent basis, following the standards set by the Greenhouse Gas Protocol, which not all mining companies do. Each of the GHGs has different global warming potential (GWP) values on a CO2-equivalent basis, using different GWP factors has a huge influence on how methane emissions are reported, Whiteside said.

"[There are] a lot of site-specific factors that wouldn't come through in just a calculation: there are different processes going on that we are now aware of, and in some ways made our analysis overall a lot more precise," he said.

Looking at Scope 3

Data are also an issue when it comes to calculating Scope 3 emissions, said Mohammed Ali, vice-president of sustainability and regulatory affairs at Agnico Eagle Mines, which uses tools created by the Greenhouse Gas Protocol to calculate its emissions. This is partially because of where mining is in the supply chain. Manufacturers, for example, have steel or aluminum suppliers with well-developed emissions profiles that allow for a clear Scope 3 picture; mining's Scope 3 footprint, meanwhile, tends to come from consumables, not all of which have clear emissions pictures. (Two exceptions are diesel production and vehicle tires.)

Then there is the question of how to calculate these emissions. One approach is to multiply the mass or volume of material purchased from a supplier by the supplier's data on how many kilograms of CO2 equivalent is produced for each kilogram of product, and do a separate calculation for the distance the materials travelled to site.

Another approach, called an economic input/output model, has started to gain traction and acceptance by the GHG protocol industry, Ali said. This method looks at how much a company spends on upstream consumables as a fraction of that overall industry: for example, if a mining company spends $100 on a consumable, and the industry that makes the consumable has $100 million in revenue, the mining company's Scope 3 footprint for that purchase is one-millionth of that industry's total contribution to total GHG emissions.

Wood Mackenzie built out Scope 3 capabilities in its EBT for a couple of commodities, but Whiteside noted there are different complexities for each commodity. With copper, it is able to track concentrate from mine to smelter. But iron ore is more complicated: the product itself will determine whether the iron is sold to a steel mill with a blast furnace, or one using a less emissions-intense direct-reduced iron (DRI) process. Iron ore emissions also differ on a regional basis, and while the company knows miners are selling more to India versus China, Europe and the United States, companies don't disclose the specifics. As well, many sales are done through traders and are therefore obscured.

MineHub Technologies, a Vancouver-headquartered company that created a blockchain platform for real-time mining and metals supply chain tracking, launched a carbon emissions tracking capability in December that chief executive officer Arnoud Star Busmann said is meant to address Scope 3 challenges.

"[Companies] take an average and say, 'from this port to [the site], these are the average emissions per kilometre for fuel.' It doesn't take into account delays, it's just pure distance. It's a rough estimate," Star Busmann said, adding that it means companies could be under- or overestimating their Scope 3 footprint.

MineHub's platform, which tracks a shipment of material from mine to eventual endpoint, now allows all players to add emissions data. Copper miners, for example, can include data on the Scope 1 and 2 emissions intensity of the copper they are shipping, along with its copper and arsenic content. Their suppliers can do the same, giving miners a clearer picture of their upstream and downstream emissions.

Star Busmann said the company is building in an analysis capacity this year, specifically for mining companies. "Big companies need to demonstrate continuous improvement in the reduction of their total emissions; investors want to see those go down," he said.

"For each customer, we have data for the shipment, product, the Scope 3 emissions for each producer. Then you can start slicing and dicing your inventory and say, for example, 'most of our emissions come from this [downstream buyer].' … You can start optimizing the portfolio." CIM

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