Decarbonizing the Mining Sector

The Sector Critical to the Energy Transition has its Own Energy Transition Plan – Will it Succeed?

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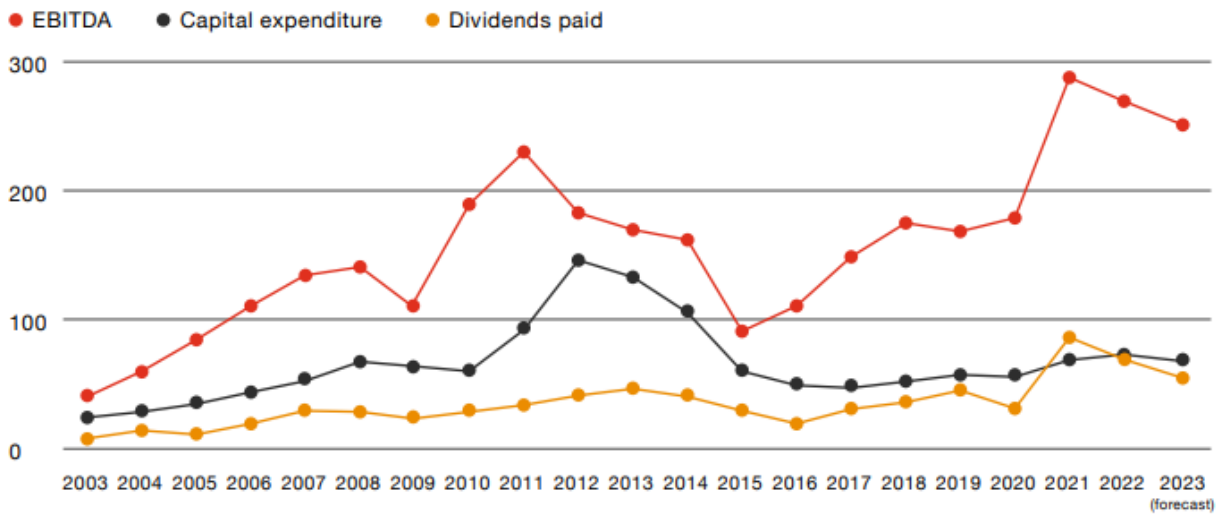
Mined metals and minerals are ubiquitous to our everyday lives. The copper in the phones we use, the steel from iron ore in the vehicles we drive, the cement from limestone that constructs the buildings we work and live, and the electricity we use to power just about everything in our modern lives - it all starts with mining. As governments and companies work to mitigate the impacts of global warming, the unfortunate truth is that our dependency on mining will only increase. To develop batteries for electric vehicles and battery storage, solar panels and wind turbines for renewable energy, and the grids needed to distribute electricity, you need copious amounts of critical minerals. However, the mines that provide these minerals today are predominantly operated by fossil fuel powered equipment and electricity. This presents a "dual challenge" for mining companies – how do they grow to satisfy the energy transition's thirst for critical minerals, while doing so environmentally sustainably?

How Much Mining Do We Need?

Today, the world mines roughly 40 million tons of minerals (including Aluminum, Chromium, Cobalt, Copper, Graphic, Indium, Iron, Lead, Lithium, Manganese, Molybdenum, Neodymium, Nickel, Silver, Titanium, Vanadium, and Zinc) per year. According to the International Energy Agency (IEA)[1] and World Bank[2], this will need to increase 4x to 160 million tons per year by 2050 to limit global warming to 2 degrees Celsius, and 4.5x to 180 million tons per year to limit global warming to below 2 degrees Celsius. That is an enormous amount of increased mining required to get the necessary Transition minerals.

There will be significant financial, technological, and regulatory challenges to meeting this first part of the dual challenge. Mining is a cyclical industry where capital expenditure is highly correlated to commodity prices, and like the oil and gas industry, publicly traded miners are focused on capital discipline after overspending in prior cycles. Mining capital expenditure will need to increase on a sustained basis for key minerals such as copper if downstream parts of the supply chain, such as smelting and fabrication, are not to be impacted by price volatility and supply constraints. As indicated below, mining capital expenditures have not always kept up with mineral price signals.

EBITA, CapEx and Dividends Paid of Top 40 Mining Companies (by $ Billion Revenue)[3]



Source: PwC's Global Mine Report, 2023

Miners also face technical and operational challenges, such as declining ore qualities and labor shortages, that impact their productivity. To help combat this, miners are leveraging remote controlled or autonomous equipment, plus site monitoring and predictive analytics solutions to increase productivity, reduce fuel consumption, and ensure safety at the mine site. Case in point, Caterpillar, Komatsu, and other equipment manufacturers have provided mining customers with over 1000 autonomous haul trucks that log over 100,000 miles in daily operations[4].

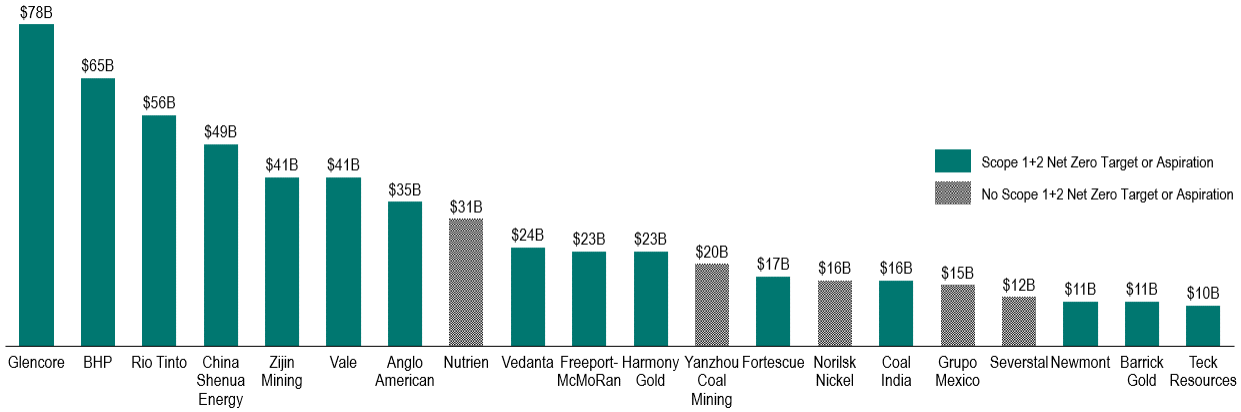
Lastly, there are non-technical barriers impeding an increase in mineral supplies. Regulatory hurdles, such as lengthy project development timelines (especially in the United States, where permitting can take 7-10+ years) increase both the costs and the risks involved in developing new mines. Once a new mine is in operation, the risk of that the resource will be nationalized will need to be carefully managed. To address these challenges, countries are seeking to diversify materials supply chains through policies that promotes domestic mineral extraction, processing, and recycling. This is seen through the European Union's Critical Raw Materials Act, the United States' Inflation Reduction Act, Australia's Critical Minerals Strategy and Canada's Critical Minerals Strategy, among others[5].

Where Do Mining Emissions Come From?

Many of the world's leading mining companies also signal they are up for the second part of the dual challenge. In response to pressure from their investors, customers, and the communities where they operate,15 of the top 20 global mining companies, have committed to net zero operational emissions[6]. These firms account for 66% of global mining revenue, so their fulfillment of these commitments can be very impactful.

Emissions from mining operations are commonly referred to as "Scope 1 Emissions" (direct emissions from operations), and "Scope 2 Emissions" (in-direct emissions from purchased electricity, heating, cooling, and steam). These account for roughly 1% of the world's annual greenhouse gas emissions[7].

Operational Net Zero Targets, Top 20 Mining Companies (by $ Billion Revenue, Last Reported)[6]



Note: Glencore revenue includes "Industrial" business line only ($256B full company revenue)

While operational emissions vary by each miner's size, products, degree of vertical integration, and location, they typically come from 3 primary sources:

- **Electricity Use** – Emissions from electricity used to power electric mining equipment and facilities. Decarbonization pathways here leverage relatively more mature technologies (e.g., solar, wind), and are typically closer to cost parity, than solutions to other emissions sources
- **Diesel Fuel for Mobile Equipment** – Emissions from the use of diesel fuel to power the mining trucks, loaders, bulldozers, etc. that move, load, haul, and dump material from mine sites. These constitute a greater challenge. The decarbonization pathways include technologies such as battery electric, hydrogen, and renewable fuel powered equipment, with many in development or pilot stages. Costs are 2-3x+ their diesel-powered equivalent.
- **Other Operational and Fugitive Emissions** – These emissions are among the most challenging. They arise from heat for processing, refining and smelting, plus fugitive emissions from methane (primarily from coal mining). The decarbonization pathways here are more unproven, with technologies typically in research and development stages, with costs forecast to be significantly higher than current processes.

How Are Miners Responding To The Emissions Challenge?

Considering the challenges involved, the mining industry is already making significant decarbonization progress.

For miners with grid connected operations, the path to electricity decarbonization will include signing power purchase agreements (PPAs) with renewable energy providers and local utilities. Using this approach, BHP has rapidly expanded the renewable share of electricity purchased from 0% to almost 50% in 2 years, largely due to purchasing 6.6 TWh of renewables to support their Chilean copper mining operations[8].

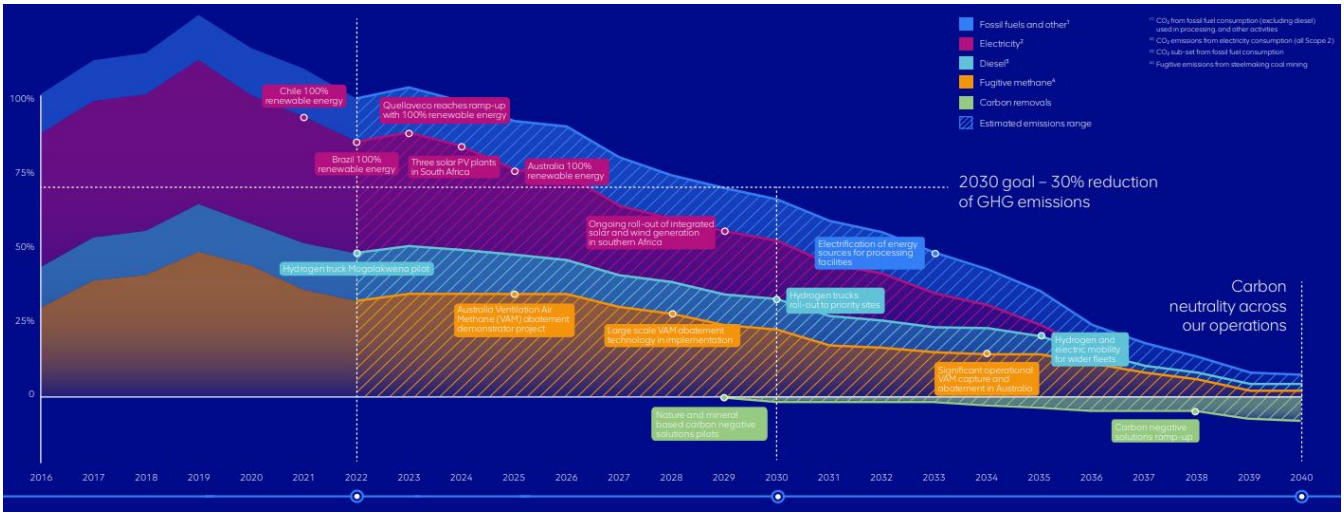
For miners in remote locations with no grid connection, electricity is typically provided through diesel and natural gas on-site generation. The first step here is to install on-site wind and solar power supported by battery energy storage systems. In 2020, Gold Fields, one of the largest gold mining companies, installed a renewable microgrid at their Agnew Gold Mine in a remote area 500+ miles northeast of Perth, Western Australia. The microgrid includes 18 MW of wind, 4 MW of solar, a 13 MW / 4 MWh battery energy storage system, and an off-grid 21 MW gas/diesel engine power plant. In total the system provides 55% of the mine's daily energy requirements and has reduced operational emissions by 42%[9]. Beyond these options, the emergence of alternative fuels such as hydrogen and ammonia may provide fuel switching opportunities. These options, however, pose significant cost and supply chain challenges.

Equipment manufacturers are also working to provide low and zero emissions solutions to reduce diesel fuel-related emissions from loading, hauling, and dumping. Battery electric underground mining loaders from Epiroc, Sandvik and Caterpillar are already in operation, reducing air pollutants and greenhouse gas emissions in the confined space of underground mining. OEMs are also trying to decarbonize the astoundingly large haul trucks used in surface mining. In November 2022, Caterpillar successfully demonstrated its first battery electric 793 large mining truck (265 ton) with support from key mining customers participating in Caterpillar's Early Learner program[10]. The mining company Anglo American, with the help of ENGIE, First Mode, Ballard and NPROXX, is piloting a 2 MW hydrogen-battery hybrid mine haul truck (290 tons) that uses a 1.2MWh battery pack, 12x the size of a Tesla Model S battery pack[11]. There are also announcements for battery electric or hydrogen large wheel loaders, excavators, and dozers. While these machines are still years from commercial operation, they signal promising options to decarbonize a critical and emissions intensive part of a mine's operation.

Lastly, miners involved in coal extraction need to think about their unabated methane emissions. These emissions have a 100-year global warming potential 28x greater than carbon dioxide[12]. Coal seams naturally contain methane, which can be released during ventilation of underground mines or during post-mining activities such as processing, storage and transport[13]. For Anglo American, 50% of their Scope 1 emissions come from fugitive emissions related to coal mining. They are developing ventilation air methane (VAM) technology to capture and oxidize these emissions, which come from lower concentrations of methane that are more difficult to capture safely by other means[14].

How can all these plans fit together? The Anglo-American chart below illustrates their plan to simultaneously reduce emissions from electricity, diesel, and fugitive methane to achieve net zero operational emissions by 2040. It's an ambitious plan but also a serious roadmap.

Anglo American's Operational Emissions Reduction Plan[14]

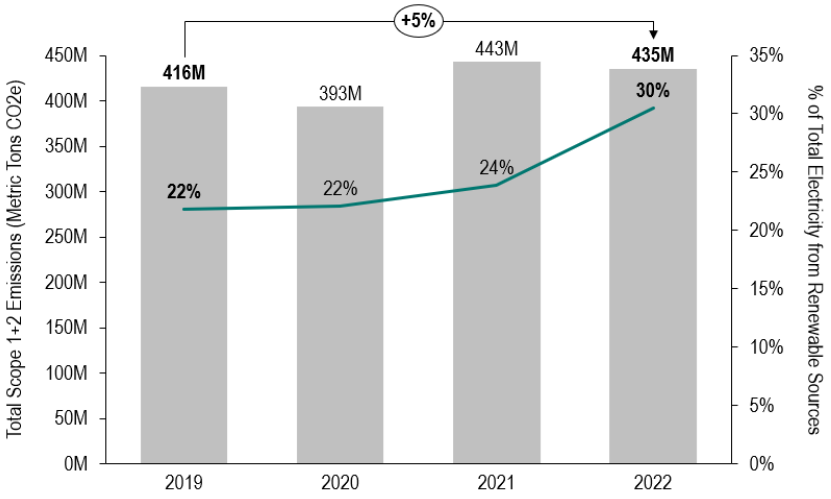


A Long Road Ahead?

While the emissions reduction commitments, investment announcements, and technology developments are encouraging, meeting the dual challenge of growing critical minerals production while simultaneously reducing emissions will be difficult.

For each additional ton of mineral needed, more energy will be required to extract, transport and process. Additionally, as mine sites work to electrify their mobile equipment, the electricity required could increase by as much as 175%[15]. This friction is shown as mining operational emissions increased 5% from 2019 to 2022, even though renewable energy as a percent of total operational electricity increased 8% over the same period.

Operational Emissions and Renewable Electricity, Top 20 Mining Companies[6]



Note: % of Total Electricity from Renewable Sources represents the average of the 12 of 20 largest mining companies that publicly disclose renewable energy consumption. Operational emissions include all 20 companies.

As miner's grapple with this challenge, the reality is that most of the technologies needed to decarbonize a mine site are still in development. They also project to have costs significantly above parity with today's options. The costs of battery packs (used in both mobile equipment and stationary storage), solar/wind power, hydrogen, etc. will need to continue down the cost curve to get to parity with their fossil fuel equivalent. It will also be important to monitor how energy transition investments expand and contract throughout business cycles. Mining companies seriously committed to decarbonization will need to baseload their spending on low carbon technologies even as their spending on new mines inevitably fluctuates with industry conditions. That said, if the forecast need for Transition minerals is correct, the mining industry may find itself planning against a more stable condition where increasing supplies are needed.

The energy transition and our modern-day society as we know it is reliant on the growth of mining, but we need it to be done sustainability for the environment and local communities. The road ahead to decarbonize this critical sector with be paved with plenty of challenges, but there are clear examples of promising technologies in the pipeline today. Time will tell how quickly, or slowly, mines are able to decarbonize, but like their broader business, we should expect to see not only peaks and troughs but an underlying trend of progress.

Sources

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