

Top 10 business
risks and
opportunities – 2020



EY

Building a better
working world

Risks and opportunities

2020

For the third year in a row, there have been significant fluctuations in the risks our clients and partners are discussing with us, along with four new risks coming into the top 10. We think this highlights the ongoing disruption in the sector. This disruption has reminded us that there are always opportunities in time of change, hence we have amended the title of our annual report to reflect this thinking.

The themes of license to operate and disruption run through this year's risks, as social responsibility and broader stakeholder demands intensify alongside the need for digital transformation, greater risk taking and innovation.

1 License to operate remains in the No. 1 slot, with 44% of our business risks survey respondents putting it at the top of the list. License to operate continues to evolve beyond the narrow focus on social and environmental issues. Any misstep can impact the ability to access capital or even result in a total loss of license. The extended period of elections and resultant government changes, along with global trade tensions, brought uncertainty to the political environment and created volatility in the commodity markets. In addition, the sector is facing greater scrutiny from end consumers, demanding a transparent ethical supply chain as well as a smaller carbon footprint. Shareholder activists are also driving many miners, particularly those with coal assets, to reshape their portfolios by either reconfiguring existing operations or executing divestments.

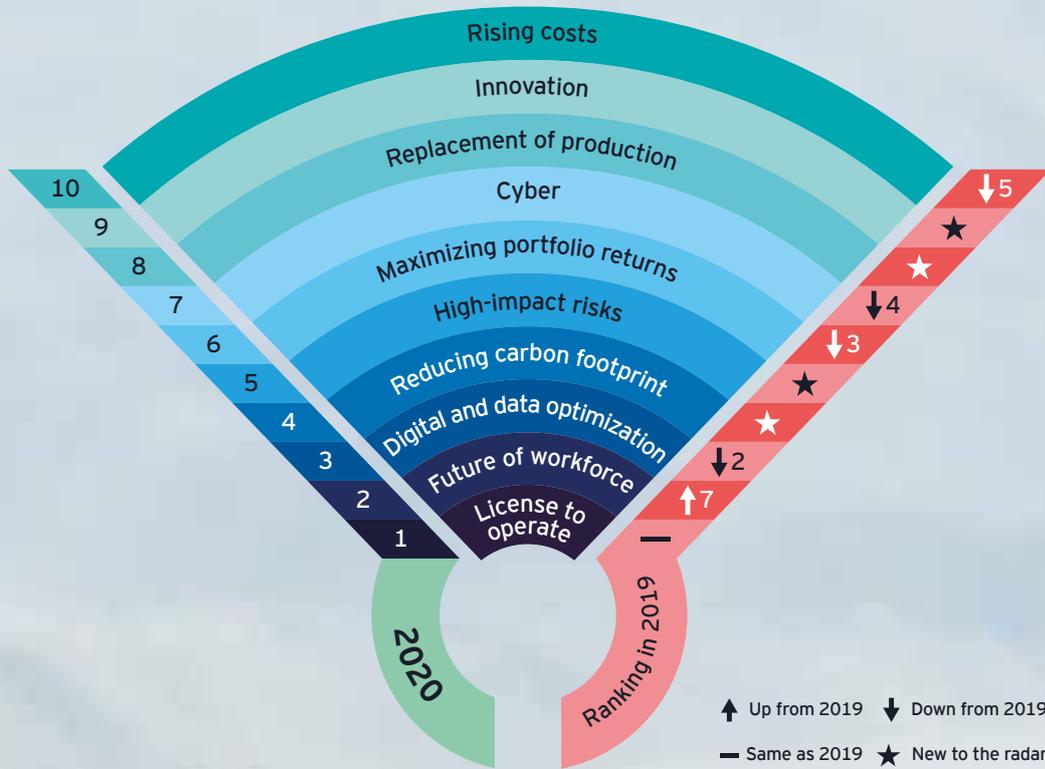
2 Future of workforce is our No. 2 risk, up from No. 7 last year, as companies struggle to determine what the workforce might look like in the future, and where they can attain these skills – through buying or building? Given the competitive market for digital and data-related skills, they might be hard to get into the mining sector, given the tarnished brand it has vs. other sectors.

3 Digital remains in the top three. While application of technology has become business as usual, is anyone really doing it well? It's more an opportunity than a risk now, and the one issue that miners find challenging is how to better manage data to extract maximum value.

Our new risks on the radar are: reducing carbon footprint, high-impact risks, replacement of production and innovation.

- ▶ **Reducing cost of carbon.** The transition to a low-carbon economy is underway, and the pressure to accelerate this transition seems to grow every day. If mining and metals companies are going to understand their exposure to climate-related risk and capitalize on the opportunities of the transition to a lower-carbon economy, they will need to properly account for their Scope 3 emissions.
- ▶ **High-impact risks.** We question whether miners have really assessed the high-impact, but often low-frequency, risks that may not be as visible to them. Company-destroying risks tend to be rare and, as a result, may not be examined. However, some of these risks may be catastrophic in terms of value destruction.
- ▶ **Replacement of production.** This is back on the radar, as miners grapple with how to meet future demand, given the challenges of opening new mines.
- ▶ **Innovation.** Given the lack of R&D spending in the sector, this could be a huge opportunity for first movers. Many clearly recognize that significant gains in productivity are possible by rethinking how work is done and by being prepared to innovate. Innovation needs to disrupt the status quo and could bring a much-needed step change to address key structural issues in the mining sector.

Top 10 business risks and opportunities



01

License to operate



License to operate (LTO) is the No. 1-ranked risk for the second year in a row, with 44% of our business risks survey respondents¹ putting it at the top of the list. Last year our view was that the stakeholder landscape was shifting, and a narrow, legacy focus on license to operate may be the strategy that puts you out of business. Applying just the social and environmental lenses, seeing it as a soft issue or allocating it to one section of the business will directly threaten your ability to operate, and underestimating the power of even a single stakeholder would be a mistake. We have seen many mining companies facing this head-on and changing their approach to LTO, which is a great start. This year, while that holistic approach remains vital, there is also a heightened focus on geopolitical risk, increased pressure from investors and the need to improve the sector brand.

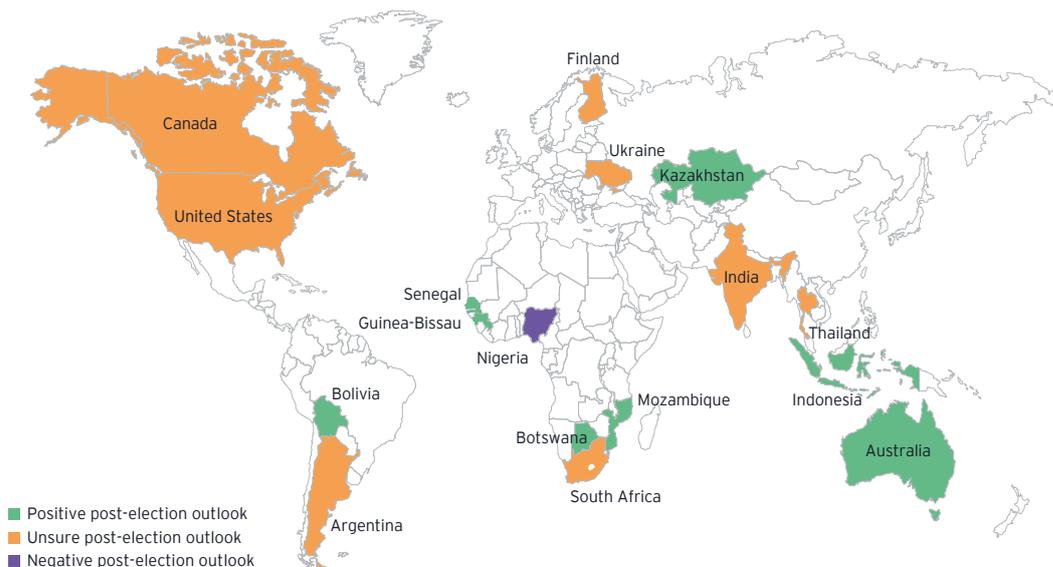
Geopolitical risk

Twenty-one percent of the EY Capital Confidence Barometer (CCB) survey² respondents believe that the regulatory environment is a key risk for investment. A number of key

elections and resultant government changes, particularly in Africa and Latin America, have created volatility for the sector and increased concern around future regulation of mining licenses and royalties. While recent elections in Australia, South Africa, India and Brazil have generally been seen as positive for the mining industry, pressure to be seen to “do the right thing” remains strong.

Investor pressure – on the rise

Shareholder activists are driving approximately 81% of our CCB survey respondents to reshape their portfolios, by either reconfiguring existing operations or executing divestments and/or acquisitions. We are already observing significant restrictions on both coal funding and underwriting, and with the Queensland Government in Australia announcing that it will significantly reduce its reliance on coal-powered energy by 2030, we anticipate this trend will continue.³ If investors don't fund the mining industry, our ability to explore, develop and innovate, particularly in the mid-tier and junior sectors, will be hampered.



¹ EY survey of over 130 executives from the global mining and metals sector.

² “How can you reshape your future before it reshapes you?” Paul Mitchell via LinkedIn, <https://www.linkedin.com/pulse/how-can-you-reshape-your-future-before-reshapes-paul-mitchell/>.

³ “21% of Queensland's power to come from renewable energy by 2019,” *Brisbane Times*, 18 July 2018, <https://www.brisbanetimes.com.au/national/queensland/21-percent-of-queensland-s-power-to-come-from-renewable-energy-by-2019-20180718-p4zs4d.html>.



Building a better brand with investors

Given the shifting societal expectations on the sector, a clear brand strategy is required. Generally, the mining sector is seen to be “old fashioned and dirty,” and so building a social bond is make or break for the sector. Many consumer companies don’t want to be associated with the sector – believing it contributes to pollution, slavery and child labor – and this is driving the requirement for greater sector transparency. We are beginning to see some progress in creating a greener brand for commodities, which is a trend we expect to continue:

- ▶ **Green aluminum:** Alcoa and Rio Tinto have announced a joint venture (JV), Elysis, around a process that produces oxygen and eliminates all direct greenhouse gas emissions vs. the typical aluminum smelting that generates 18 tons of CO₂ per ton of smelted aluminum. The provincial Government of Quebec will have a 3.5% equity stake in the JV.⁴
- ▶ **Copper Mark:** the International Copper Association has created a framework to demonstrate the strong sustainability performance of the entire copper industry and will influence how mine sites operate and interact with local communities, governments and supply chains. Those companies that adhere to this framework will be awarded the Copper Mark, and we believe this will enhance sales and value for those that have it.

Miners need to be part of the solution, hence their engagement around topics such as the circular economy and green mining of the future are key. BHP’s announcement⁵ to invest US\$400m to reduce carbon emissions really puts a stake in the ground, and we discuss this more in the *Reducing carbon footprint* section of this paper.

We believe that now is the time for greater collaboration within the sector and for communities, associations and governments to really help shape the messaging of the societal contribution and value derived from the mining sector. The Minerals Council

of Australia’s 30 things campaign⁶ has been a step in the right direction from an Australian context. It raises awareness of the mining sector’s contribution to everyday living, including electricity, smartphones, health care and public transport.

Creating long-term value through LTO

In 2018, a cross-industry working group of 31 organizations, including EY and the Embankment Project for Inclusive Capitalism (EPIC), produced a report⁷ on the value drivers important for sustainable and inclusive growth, as well as the potential metrics to assess them. Today, a company’s value is reflected not just in financial terms, but also by intangible assets, such as talent, innovation and impacts on society. To understand this value, participants in EPIC believe it is essential to focus on and measure:

- ▶ **Talent:** the way companies manage their human capital when it comes to compensation and benefits, recruitment, training and development, diversity and inclusion, well-being, and creating a purpose-driven culture of engagement
- ▶ **Innovation:** fulfilling unmet needs, maintaining focus on the end user during the innovation process and fostering trust in the organization
- ▶ **Society and environment:** the impact on external stakeholders and communities by contributing to business-relevant social and environmental goals
- ▶ **Governance:** the effectiveness of the board in providing appropriate oversight, governance mechanisms to ensure board quality and independence; and the ability of leadership, in conjunction with the board, to develop and assess long-term strategy

We think this creates a real opportunity for the mining sector to redefine how and what they report to all stakeholders, not just shareholders.

⁴ “Rio Tinto and Alcoa announce world’s first carbon-free aluminum smelting process,” *Rio Tinto Press Release*, 10 May 2018, https://www.riotinto.com/media/media-releases-237_25362.aspx.

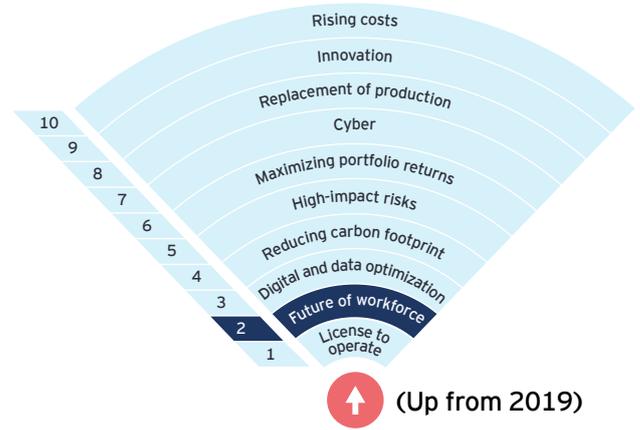
⁵ “BHP invests \$400m to address climate change,” *BHP Press Release*, 23 July 2019, <https://www.bhp.com/media-and-insights/news-releases/2019/07/bhp-to-invest-us400m-to-address-climate-change>.

⁶ “30 things: Everyday things mining makes possible,” *Minerals Council of Australia*, 2019 <https://minerals.org.au/sites/default/files/30%20Things.pdf>.

⁷ “Embankment project for inclusive capitalism report,” *Coalition for Inclusive Capitalism*, [https://www.ey.com/Publication/vwLUAssets/ey-at-embankment-project-inclusive-capitalism/\\$FILE/EY-the-embankment-project-for-inclusive-capitalism-report.pdf](https://www.ey.com/Publication/vwLUAssets/ey-at-embankment-project-inclusive-capitalism/$FILE/EY-the-embankment-project-for-inclusive-capitalism-report.pdf).

02

Future of workforce



Digital and technological innovation have the potential to provide step-change improvements in productivity, safety and environmental management within the mining industry. However, to achieve this, in addition to significant investments, a different workforce will be required, and the sector is grappling with what this looks like and where to begin the transition.

Shifting operating models and location of work

Driven by the shift to a more market-centric operating model, the pace of technological change and the need to collaborate to outcompete, the concept of what constitutes a workforce is set to shift. Workforces are set to become far more dynamic as skills will need to be acquired flexibly to meet changing needs, resulting in an increased reliance on nontraditional workers.

Automation of repetitive tasks is enabling mining companies to free up staff for higher-value work. It also has a significant health and safety benefit, as it reduces exposure to hazardous work environments and eliminates operator fatigue. With technological advancements, we have also seen a shift to integrated or remote operating centers, locating workers closer to population centers and attracting new and potentially more diverse employees. However, this doesn't come without license-to-operate challenges, as the move away from regional communities can create a barrier to engagement.

Workforce composition

In a recent EY study commissioned by the Minerals Council of Australia, we found that 77% of occupations in the sector will be enhanced or redesigned by 2030 because of technological advancements. Skills of the future present themselves as resistant to the impact of automation, or those skills enhanced by technology, resulting in greater productivity. Science, technology, engineering and mathematics (STEM) skills, such as data and digital literacy skills, will be in high demand across

all phases of the mining value chain as the human-to-machine interface evolves and becomes more prevalent. The demand for skills can be expected to increase in the future and play an important role in enhancing decision-making and optimizing everyday work.

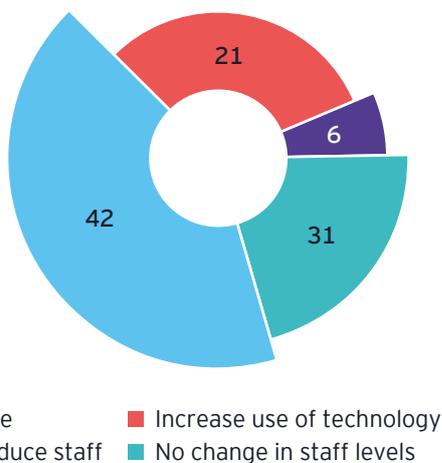
Furthermore, tasks that have elements of social intelligence, perception and manipulation, and creative intelligence are domains where digital technologies have yet to surpass human endeavor (Frey & Osborne, "The Future of Employment," 2013). Hence other skill sets in demand are those with an emphasis on softer skills and judgment, such as collaboration, stakeholder engagement, design thinking and effective change management, all of which help to build adaptability and organizational resilience to the impacts of technology and automation.

The war for talent ... it's heating up

The attractiveness of the mining sector as an employer has declined over the last decade due to the cyclical nature of employment, high-profile disasters and the perception that it lags other industries on innovation, diversity and sustainability. Lower university enrollments for sector-focused engineering and science degrees highlight the impact. In addition, the sector suffers from an aging workforce and is facing a loss of operational and executive knowledge due to retirements. In terms of priorities for employment strategies, 42% of the EY CCB respondents said they were looking to hire, so the war for talent looks set to escalate. Showcasing the value mining brings, plus selling the narrative of the future of mining, is key to attracting the next generation of workers. Not only is the sector facing increased competition for labor within the sector but also from other sectors. Given the pace of transformation, there is increasingly a mismatch between the available labor pool and the competencies and characteristics required, and miners will need to be quick to address this.



Priorities for employment strategy



Source: EY survey of over 130 executives from the global mining and metals sector.

Leadership and culture

Forty-eight percent of respondents to our business risks and opportunities survey cited leadership and culture as critical factors constraining digital transformation. To accelerate digital transformation and enable high performance under the customer-centric operating model, changes will be required. For decades, successful mining leaders have been rewarded for risk-averse decision-making and relentless focus on efficiency through loss elimination. To create conditions conducive to digital transformation, mining leaders now need to also encourage innovation, with new ideas, experimentation, and a culture that celebrates and learns quickly from failure.

Operations have traditionally been king, with site leadership empowered to make strategically critical production decisions. As more and more of the value chain becomes centrally

managed, and traditional silos are eliminated, remote decision-making has the potential to create dissonance with local leadership. Clearly, this will need to be carefully managed.

How to grasp the opportunity

To smoothly transition to the future, management will need to have a strong foresight of digital transformation across the value chain and an aligned vision for the company to implement the right technological innovation, while upskilling the workforce. Shaping team culture, building trust and developing clear learning pathways need to be at the heart of this vision.

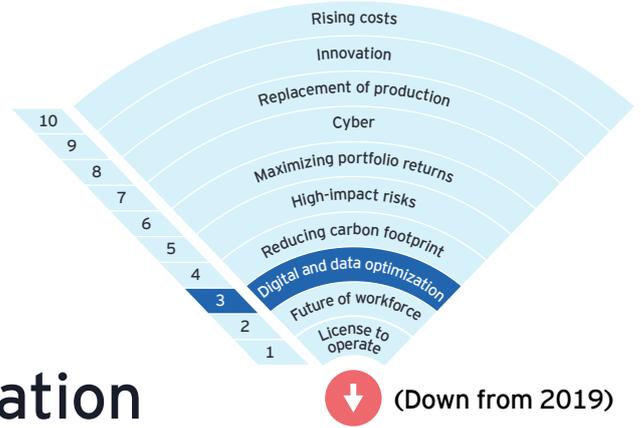
Some questions to consider:

- ▶ How are you going to build, recruit or borrow the right skills and capabilities across the organization?
- ▶ How will you retain senior employees to minimize the negative impact of attrition?
- ▶ How do you create a compelling employee value proposition?
- ▶ How will you equip future leaders with the skills needed to manage teams in a digital age?
- ▶ What creative strategies can you employ to ready your workforce for the future?

By better understanding the future skills required, miners will be able to strategically plan their workforce and sustain their competitive advantage in global markets. Our advice would be to start with the end in mind and begin planning now. Many of these forces are impacting the sector now, and further change is coming sooner than you expect.

03

Digital and data optimization



Digital remains in the top three

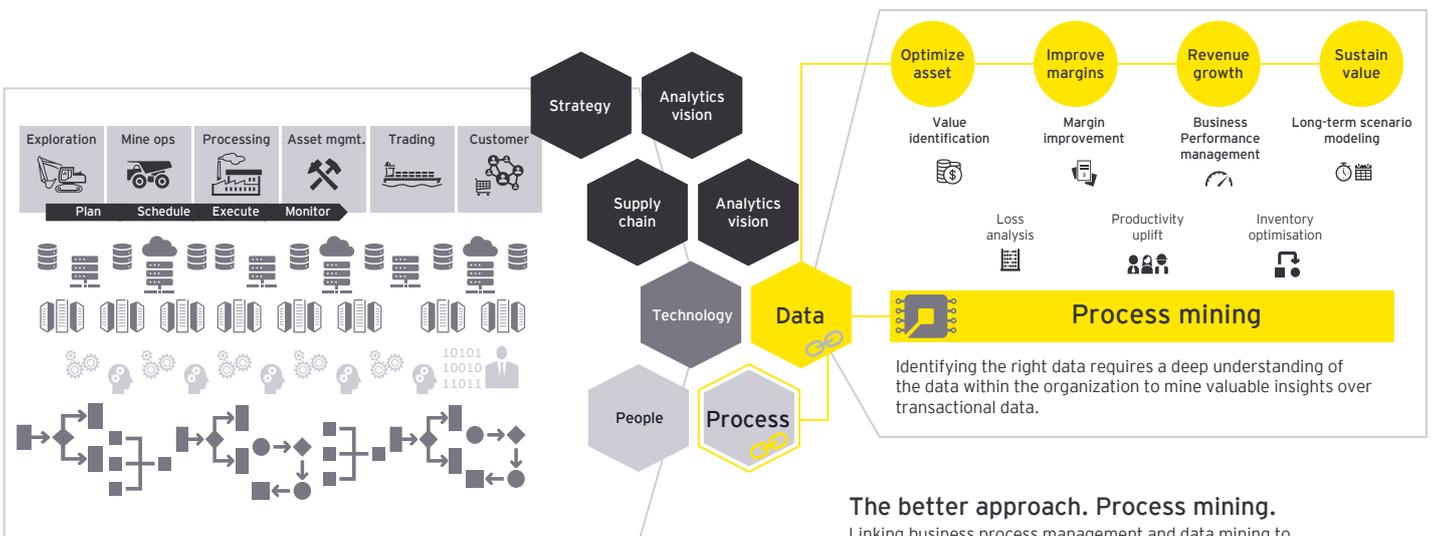
Digital effectiveness remains in the top three risks and opportunities for miners and continues to be a topic executives want to discuss. It is the key to sustainable productivity and margin improvements, and getting it right will be a key differentiator. In addition, technological innovation has the potential to provide major improvements in safety within the mining industry and will enhance LTO.

Miners have continued to make some good headway in the digital transformation of their businesses with automation and analytics almost business as usual. We have also begun to see the use of digital twins to help unlock productivity across the value chain, and many companies are now using the term “integrated operations center” rather than “remote operations center,” further demonstrating the adoption of end-to-end

solutions. True end-to-end approaches are key, as this is what is required to enable a 10% to 15% uplift in productivity. To do this, mining companies will need to think more broadly about potential capacity and how to unlock that, rather than business improvement.

Data – the missing link

Our clients tell us that both obtaining the right data and making it actionable are critical components to unlock the value from digital investments. Data holds the key to increasing performance while minimizing costs. It enables decision automation to minimize loss across the entire value chain; to maintain assets before they fail; and to improve the health, well-being and productivity of staff.



The better approach. Process mining.

Linking business process management and data mining to quantify business processes and the data used to execute them

The data landscape is complex to navigate and prioritize. The ability to truly understand what data is important and how to extract value from it has not been achieved to date. There has been a rush to connect every piece of equipment, as companies thought this alone would enable a huge step change. Instead, this has only added to complexity and has cost a lot of time and effort. Getting this right will be a source of competitive advantage for companies that have the right data available at the right time to inform decision-making.

Identifying the right data requires a deep understanding of the data within the organization and what data is valuable vs. merely transactional. One approach to answering this question is process mining.

Process mining is a combination of business process management and data mining. This highly visual methodology quantifies business processes and the data used to execute these processes. An enterprise-wide data value chain can then be created to allocate a tangible value to each business process.

This provides management with a clear view of what data is valuable and where investments should be made. Improved decision-making and a fact-driven culture are two of the outcomes from a considered and strategic approach to data management. The process mining methodology represents a significant opportunity for the mining industry to quickly differentiate, and first movers will gain a competitive and sustainable advantage.

Data optimization is a huge untapped opportunity for the mining sector. Success requires a clear intent on what issues we are trying to resolve and what the outcome should be so that the appropriate actions can be taken and value realized. Thus, the more time spent understanding where the value from the data lies, the better the outcome.



04

Reducing carbon footprint

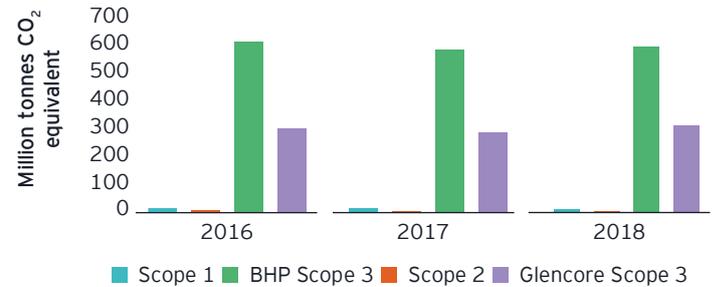


Miners pressured on carbon emissions and energy use

Pressure is being put on miners to reduce their impact in terms of both carbon emissions and energy use.

The transition to a low-carbon economy is well underway, and the pressure to accelerate this transition seems to grow every day. Leading mining companies are recognizing the importance of reducing their carbon emissions.

Top five mining companies – average Scope 1 and 2 CO₂ emissions compared to BHP and Glencore's Scope 3 emissions (2016-18)



Source: EY analysis of annual sustainability reports.

Emerging risk: Defining the extent of your responsibility for emissions

- ▶ **Scope 1:** direct emissions from owned or controlled sources
- ▶ **Scope 2:** indirect emissions from generation of purchased energy
- ▶ **Scope 3:** all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions

Most of the large miners report on their Scope 1 and 2 greenhouse gas emissions, but not all report on Scope 3 emissions. The importance of Scope 3 emissions becomes clear when you consider that mining companies generate around 11% of global greenhouse gases (GHG) directly, but when the burning of coal is included, this rises to over 35%.⁸

Mining companies are therefore seeking to define the extent of their responsibility for emissions. GHG data from the top five mining majors shows a slight decline in Scope 1 and 2 emissions over the last three years. However, these emissions are almost insignificant compared to the Scope 3 emissions.

According to the World Bank, mining accounts for 11% of global energy use,⁹ and the cost is significant for mining companies – up to one-third of a mining company's total cost base, making it

a keenly managed component of operations. But, over the past 30 years, energy cost pressures have been steadily increasing as average grades have halved, and overburden has doubled. Mines are extending to greater depths, increasing the demand for power. Energy demand from the mining sector is expected to increase by 36% by 2035.¹⁰

Minimization strategies

1. Renewable energy

Swapping diesel for electricity is a way forward, but only if it comes from renewable sources. While in the past clean energy was not cost effective, costs have fallen, quickly putting renewables on track to outpace all other sources of energy and account for 60% of all energy capacity additions by 2040. According to Fitch Solutions, there is already one gigawatt (GW) of renewables built at mine sites across the world, and another one GW in the pipeline. The transition appears to be well underway.¹¹

⁸ "Mining DECAF- Why decarbonisation and rising CO₂ costs matter for the miners ... today," *Deutsche Bank*, 11 June 2018, via ThomsonONE, accessed in July 2018.

⁹ "Climate-Smart Mining: Minerals for climate action," *The World Bank*, June 2017, <https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action>.

¹⁰ "The renewable power of the mine: accelerating renewable energy integration," *Colombia Center on Sustainable Investment*, 10 December 2018.

¹¹ "Energy-intensive mining companies look to renewables for cost savings," *Institute for Energy Economics and Financial Analysis*, 11 September 2018, <http://ieefa.org/energy-intensive-mining-companies-look-to-renewables-for-cost-savings/>.

Several mining and metals companies have announced plans to increase their uptake of renewable energy, particularly in Chile. Codelco and Antofagasta are introducing solar and wind energy.¹² More recently, Anglo American announced it will only use renewable sources from Enel to power its mine operations in Chile beginning in 2021. The company estimates this will help it reduce its total CO₂ emissions in Chile by over 70%.¹³

The integration of conventional and renewable sources is critical to ensure reliable and safe power for mines, with people working underground often relying on power for lighting and ventilation. If the sun stops shining or the wind stops blowing, the conventional sources of energy or stored energy have to cover the shortfall. It is this factor that causes some renewable projects to be put into the “too-hard basket,” and conventional solutions persist.

2. Electrification of mines

Electrification of mines will be a big factor in reducing carbon emissions and costs. Around the world, more and more mining companies are looking closely at options to electrify their mines, motivated by the potential to cut costs, boost their license to operate and contribute to a more sustainable sector.

As mines seek to reduce costs and greenhouse gases, they will be investigating ways to replace diesel-powered equipment with electric equipment, particularly as battery storage technology becomes more reliable and affordable. One area in which this will have significant impact is an estimated 30% reduction in ventilation costs. The Global Mining Guidelines Group and Canada Mining Innovation Council outline the recommended practice for the use of battery electric vehicles (BEVs) in an underground mining environment. It can be used by both mining companies and original equipment manufacturers (OEMs) in designing and accommodating BEVs. It aims to strike an appropriate balance between standardization and innovation, providing a global scope while acknowledging that regional differences exist in standards and regulatory frameworks.¹⁴

3. Focus on Scope 3 emissions

If mining and metals companies are going to understand their exposure to climate-related risk and capitalize on the opportunities of the transition to a lower-carbon economy, then it is inevitable that they will need to properly account for and eventually reduce their Scope 3 emissions.¹⁵ This will mean companies will have to assess the markets they sell to and consider the impact of selling to customers who produce substantial emissions in the use of their products.

According to the GHG Protocol, businesses have found that developing corporate value chain (Scope 3) and product GHG inventories delivers a positive return on investment.

The new standards help companies to:

- ▶ Identify and understand risks and opportunities associated with value-chain emissions
- ▶ Identify GHG reduction opportunities, set reduction targets and track performance
- ▶ Engage suppliers and other value-chain partners in GHG management and sustainability
- ▶ Enhance stakeholder information and corporate reputation through public reporting¹⁶

Several large miners are highlighting the extent of their Scope 3 emissions. While there are currently no regulations on Scope 3 emissions, it is possible that these indirect emissions in the value chain of miners could be regulated in the future.

The opportunity

The clean energy transition is going to be mineral intensive, providing an enormous opportunity for mining companies. There are significant opportunities for lithium, cobalt, copper, aluminum, nickel and many other minerals. Global production of several rare earth metals used in the production of solar panels and wind turbines will need to increase twelvefold by 2050 if all signatories to the Paris Agreement live up to their commitments to decarbonize their economies.¹⁷

¹² “CEEC’s latest workshop to examine new gen energy options for miners,” *International Mining*, 5 June 2019, <https://im-mining.com/2019/06/05/ceecs-latest-workshop-examine-new-gen-energy-options-miners/>.

¹³ “Enel signs with AngloAmerican in Chile Group’s largest renewable energy supply deal,” *Enel press release*, 30 July 2019, <https://www.enelgreenpower.com/media/press/d/2019/07/enel-angloamerican-chile-renewable-energy-supply-deal>.

¹⁴ “Recommended practices for battery electric vehicles in underground mining v2.0,” *Canada Mining Innovation Council*, https://gmggroup.org/wp-content/uploads/2018/11/20180621_UG_Mining_BEV_GMG-WG-v02-r01.pdf, accessed 12 April 2019.

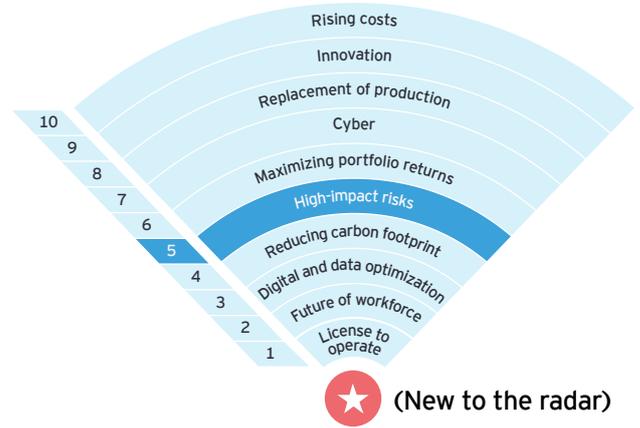
¹⁵ “Scope 3 Emissions Calculation Methodology 2018,” *BHP*, September 2018, <https://www.bhp.com/-/media/documents/investors/annual-reports/2018/bhpscope3emissionscalculationmethodology2018.pdf?la=en>.

¹⁶ “Greenhouse Gas Protocol - FAQ,” *GHG Protocol*, https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf, accessed 21 August 2019.

¹⁷ “Metal demand for renewable electricity generation in the Netherlands,” *Metabolic, Universiteit Leiden, Copper8*, 2018, <https://www.copper8.com/wp-content/uploads/2018/12/Metal-Demand-for-renewable-electricity-generation-in-the-Netherlands.pdf>.

05

High-impact risks



Does the traditional risk matrix work for a mining company?

Most mining companies can clearly state their critical risks from an operational perspective and do a good job of managing the visible, high-frequency risks in their business.

However, in our experience, these critical risks are often static and stay on the risk register in much the same “format” for many years. These risks may be reviewed but are often just “rolled over” from year to year. With the rising focus on improving the brand of the sector and managing reputational risk, companies are becoming more aware that risk and trust are inextricably intertwined. In fact, loss of trust is possibly the biggest risk that a business can ever face since everything else depends on it.

Major events, such as train derailments and tailings dam failures, which have occurred in recent years, are therefore a reminder to everyone that these risks must be reviewed on a regular basis. With respect to tailings dams, many of the companies we have talked to have now reviewed in detail the risk associated with tailings dams and other decommissioned assets, both in terms of their potential impact as well as how the risks are being managed. Risks around decommissioned assets have been particularly susceptible to being “rolled over,” as the primary asset does not change like an active mine.

Traditional risk matrix

	Insignificant	Minor	Moderate	Major	Catastrophic
	1	2	3	4	5
Almost certain	M	H	H	E	E
Likely				H	E
Possible				H	E
Unlikely	L			H	H
Rare	L	L	M	M	H

Typical mining risk distribution



We have also started to question whether companies have really assessed the high-impact but often low-frequency risks that may not be as visible. Company-destroying risks tend to be rare and, as a result, may not be examined. However, some of these risks may be catastrophic in terms of value destruction.

A good example of such a risk is the impact the Fukushima nuclear accident had on the value of uranium resources. From 2003 to 2009 the market price of uranium rose from under US\$20/lb to US\$155/lb, and many commentators talked about uranium being the logical source of carbon-free power. Any gains made after the global financial crisis were wiped out by the impact of the tsunami. By November 2016, uranium spot prices hit a low of US\$17/lb, and the value of uranium assets was similarly impacted.

Critical risks in the future may not be highly publicized risks, such as the impact on people and the environment from mining accidents. They could also be the result of market or industry disruption. One such risk that may impact companies, particularly those focusing on a single commodity, is the threat of substitutes, which can be extremely destructive to companies if not managed. In the US, the shale gas boom and gas-for-coal substitution that occurred in 2012-13 was sudden, and the impact was unexpected and resulted in the closure of more than 50 coal mines over those two years.

The threat of substitution is a risk that can unexpectedly build momentum, should the right conditions prevail. Once substitution starts occurring, it could cause a structural shift in consumer habits, making it potentially irreversible.

Companies need to assess portfolios in terms of what would happen if something radical happens. For example, what if:

- Energy becomes free, then what happens to copper?
- There is a massive technological breakthrough in the composition of plastic or other advanced materials – how does that affect demand for metals?

By thinking through these types of questions, companies will be able to rebalance portfolios to tap into new resources, reduce exposure of substituted commodities and keep abreast of emerging trends across commodities for timely intervention.

Companies need to build in the flexibility to pivot as necessary to meet sudden unexpected changes. As you can't predict the future, it's about imagining the future and preparing for different hypotheses of that future. The first step is to develop a shared view of how value is created and which are the important relationships, both within their value chain and with external players. With that common understanding of value drivers in place, companies can scrutinize the effect of possible high-impact events on companies through scenario analysis.¹⁸

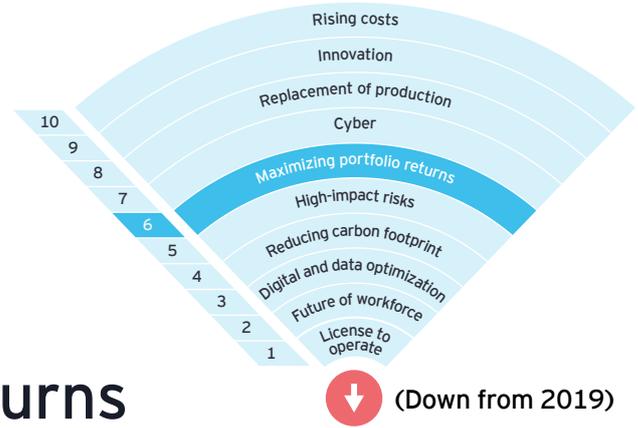
Leading organizations today are also taking a real-time read of their key risks with the help of data analytics and artificial intelligence. With a big data set of all potential risks, and live access across an entire organization, leaders can spot trends quickly and make decisions on the basis of real data, rather than through guesswork and a gut feeling.

Building effective risk management into new business models, products and services, so the right decisions can be made, is how organizations can create trust by design. And with that trust comes growth. Trust is the bedrock on which value is created because it's only through trust that we build the confidence of stakeholders and the confidence to seize transformative opportunities.

¹⁸ "Getting From There To Here: Stress-Testing Today's Capital Agenda With Tomorrow's Scenarios," *Harvard Business Review and EY*, 10 May 2016, <https://hbr.org/sponsored/2016/05/getting-from-there-to-here-stress-testing-todays-capital-agenda-with-tomorrows-scenarios>.

06

Maximizing portfolio returns



The long-term capital objective of the industry is: *to increase the level of return on capital, while at the same time reducing the volatility of those returns.*

The big problem, of course, is that over the last decade mining has been impacted by volatility and averaged just 7%-8% return on capital. Most recently, miners have sought to address this by returning capital back to shareholders, boosting short-term returns. While this is a valid strategy, it can't continue forever. Miners need to think more broadly about how to maximize their returns, and adopt new approaches that may be radically different from those of the past. Mining companies will also need to re-evaluate their appetite for risk to ensure they are not missing out on new opportunities by taking a complacent or conservative approach to allocating capital.

Some areas for consideration:

1. Funding transformation

The industry will increasingly look to accelerate payback on capital, i.e., invested capital must be able to generate positive cash flow quicker. This reduces the balance sheet burden, with negative capital positions held for a shorter period. Innovation will be key to this, with better discovery techniques, faster data processing to facilitate accelerated feasibility studies and permitting, and, ultimately, a change in the way mines are developed, with a greater emphasis on agility and flexible mining. However, the scale of investment that has historically gone into capital projects dwarfs that for transformation projects. In addition, the difficulty in measuring return on investment for innovation projects has proved to be a barrier to greater outlay of capital.

Companies prepared to invest in innovation will gain a significant competitive edge. Miners who invest in technology, data analytical capabilities and operational transformation will have an edge over their competitors.

The investment in innovation and technology could be disruptive to the way mining and metals organizations operate, giving distinct competitive advantage to early adopters. Collaboration with OEMs and technology vendors would be a key step as miners build in flexibility; for example, the collaboration between Newmont Goldcorp, Swedish OEM Sandvik and Canadian OEM MacLean Engineering at the Borden gold mine in Canada.

2. Rethinking portfolio

- ▶ **Responding to climate-change pressure.** There is growing climate-change pressure from investors and regulators on mining companies to reshape their portfolios. As a result, large miners are either divesting or considering divesting their coal assets. For example, Rio Tinto exited the coal business in 2018, and at the time, CEO J.S. Jacques said: "Given our decision to strengthen our business and exit coal, we are now the only major mining company with a fossil-fuel-free portfolio, which means we are well-positioned to contribute to a low-carbon future."¹⁹ Some investors are also announcing a cessation of finance for certain coal projects. For example, DBS Bank will stop financing low-grade coal projects by the end of this year but continue to support ventures in emerging markets that use higher-quality coal, as coal will still account for 40% of the energy mix by 2040.
- ▶ **Diversifying to future minerals.** Greater returns can be generated by having the right portfolio to respond to industry disruption. The shift from fossil-fuel-powered vehicles globally to electric vehicles (EVs) has resulted in increased interest from downstream sectors seeking to invest in prime lithium assets. Wesfarmers and Pluspetrol are the first industry outsiders to enter the market. European Union-based OEMs are also investing

¹⁹ "Rio targets a low carbon economy," *Australian Financial Review via Factiva*, accessed 12 July 2019.



aggressively into EVs; for example, a large automotive manufacturer plans to vertically integrate its supply chain. Coal miners are operating in a continuously challenging environment with respect to demand and energy mix. Some miners are either using venture capital firms or setting up specialist internal teams to identify more specialized mining prospects as they seek to capture value beyond their core portfolios. For example, Rio Tinto Ventures is assessing new opportunities based on key new technologies that will influence future metal demand.

- ▶ **Evaluating current portfolios.** It's equally important to assess current assets to ensure capital is being allocated optimally across the portfolio and synergies between assets are being captured. There may also be opportunities to leverage existing assets to obtain greater premiums – for example, blending iron ore to customer specifications or implementing innovative trading strategies. Divestment of noncore assets to drive capital into more valuable parts of the business is also an option, e.g., AngloGold Ashanti's divestment of its South African assets in order to invest in the rest of its portfolio.
- ▶ **Replacing reserves.** As we highlight in *Replacement of production* the mining sector needs to rethink ways of developing known resources, finding new deposits and getting more out of deposits. M&A has been a focus for major gold miners seeking to boost current reserves, most notably the Barrick Gold and Randgold combination.

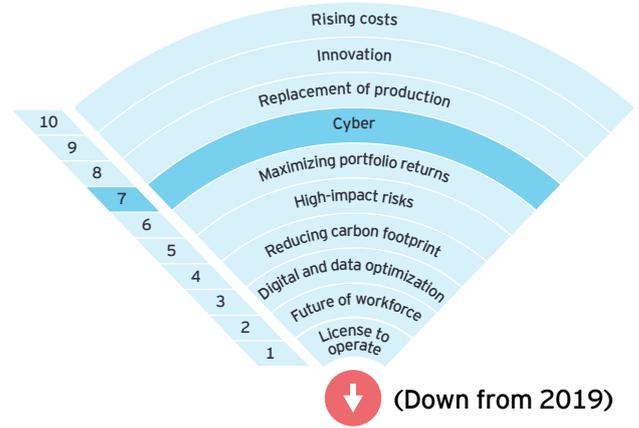
3. Joint ventures

- ▶ Undertaking capital projects with JV partners will help to reduce the financing risk and spread capital across a greater number of investments (which may include reducing debt and/or returning capital). Increasingly, these JV partners will come from a greater pool of participants, most likely incorporating the technology manufacturers.

Companies are securing greater control of the supply chain without incurring the associated capital. For example, Glencore has entered into a long-term cobalt hydroxide agreement with European recycler Umicore, which is continuing to build out its battery-metal offering. At the same time, automakers may invest directly in battery metals to secure supply as the market predicts supply shortfall.

Greater data analytics capabilities within organizations can greatly improve the ability of companies to manage their portfolios. Effective use of data can allow companies to identify assets that become off-strategy quickly. In addition, the performance of portfolio assets can be better monitored and the true value contribution of those assets can be assessed on the back of greater integration with operational and financial metrics.

07 Cyber



Data holds the key to increasing productivity while minimizing costs. It enables decision automation to minimize loss across the entire value chain. As digital becomes business as usual, the threat surface that can be attacked is increasing exponentially. This is largely due to the convergence of information technology (IT) and operational technology (OT), Internet of Things (IOT) sensors, data analytics, and optimization AI.

In addition, as the workforce adopts more agile ways of working, individuals can access enterprise networks from any location via a greater number of devices. This increases the footprint of cloud-based platforms, business solutions and data repositories. The security of the enterprise perimeter is therefore based on user identity, and companies need to have a “trust by design” strategy embedded to ensure security around how employees are accessing data for both in-house and externally developed applications.

Over the last year, mining and metals companies have focused on the “basics” – locking down highly privileged corporate accounts (e.g., domain administrators), routine patch management and vulnerability management (i.e., penetration testing), multifactor authentication, security awareness, and a cyber crisis simulation.

However, mining and metals organizations are still a long way from protecting operational systems. This is a fundamental issue that should be keeping the boards of mining companies awake at night. The risk of a breach through corporate systems to the operational systems is something that the industry needs to deal with. The impact of an attack on OT includes prolonged and widespread outages, safety incidents, liability claims and associated legal costs, data cleanup costs, reputational damage, management distraction, and physical damage to assets.

Recent data from the Mining and Metals Information Sharing Analysis Center (MM-ISAC) initiative also indicates that ransomware is a major issue again – this time in control systems due to a lack of security hygiene. Third-party breaches are an increasing risk as many mining companies, as well as EPCs (engineering, procurement and construction) and OEMs, lack

cybersecurity plans, processes and expertise.²⁰ Email phishing is still a constant threat, and there have been a significant number of phishing campaigns run against mining companies.

Global mining companies are collaborating to improve cybersecurity through the MM-ISAC initiative. The MM-ISAC facilitates the sharing of critical cybersecurity information through secure channels, enabling member companies to benefit from this intelligence at a reasonable cost. The initiative aims to advance research, cooperation and training to minimize and protect against incidents that could impact safety, environmental sustainability or operational productivity. In Australia, federal agencies are also engaging, supporting and sharing threat intelligence with mining companies to enable better protection.

An innovative cybersecurity strategy based on good risk management principles needs to be applied

While most mining companies have cyber on their enterprise risk register, the “real” cyber risk may be understated or not well defined enough to accurately assess the control effectiveness and residual risk. The focus should be on how cybersecurity will support and enable enterprise growth. The aim should be to integrate and embed security within business processes and build a more secure working environment for all. This is particularly important in light of the changing technology landscape, a more agile workforce and the push for technology to be more flexible and “customer focused.”

Every cybersecurity transformation should promote three key principles across culture, governance and capabilities:

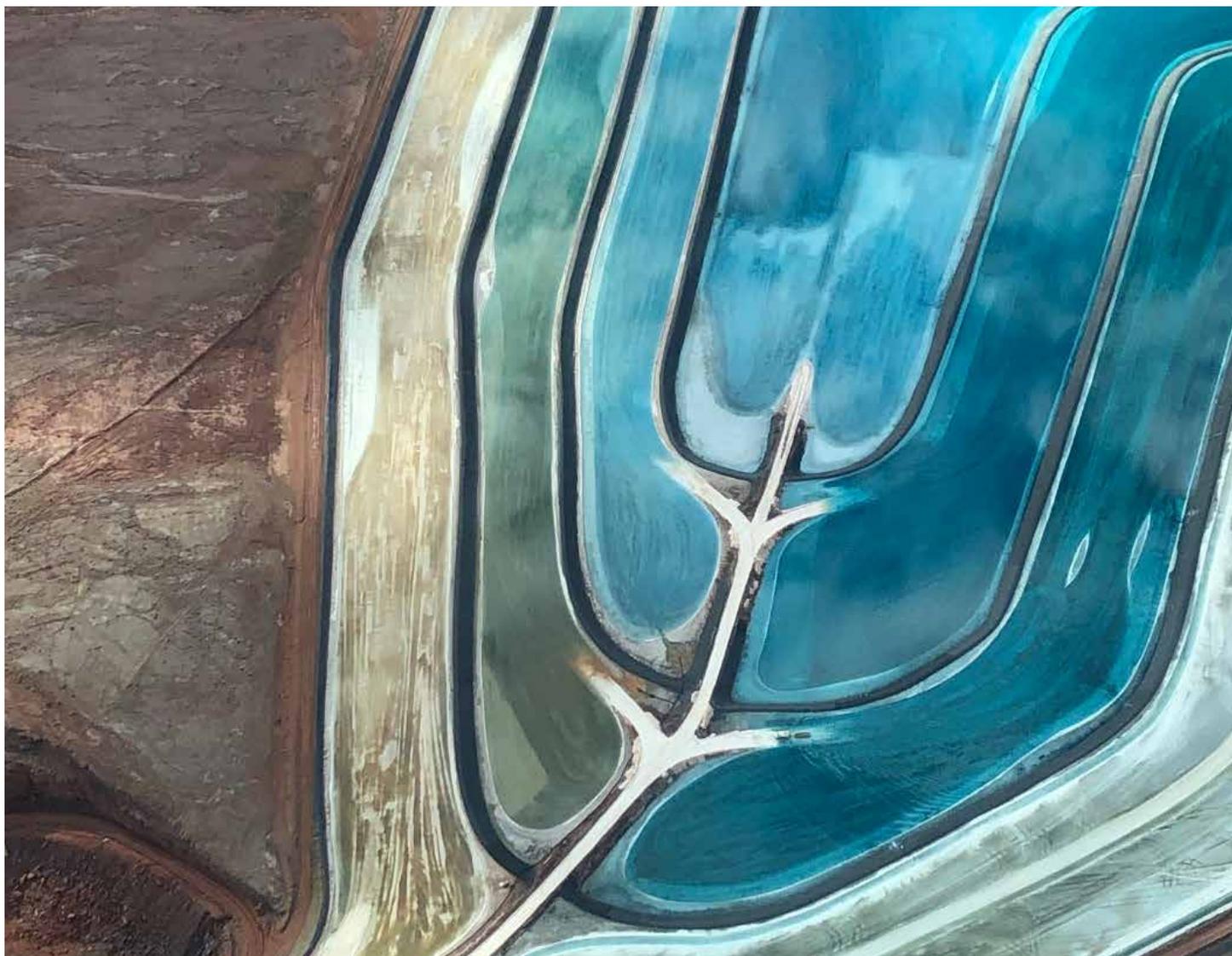
1. **Excellence in security fundamentals.** Be highly mature at “security basics,” practice good security hygiene and optimize your current information security solution capabilities. Security basics include the locking down of highly privileged corporate accounts (e.g., domain administrators), routine patch management and vulnerability management (i.e., penetration testing), multifactor authentication, security awareness, and a cyber crisis simulation.

²⁰ Teck Mining presentation to the Austmine Conference, Brisbane, 21-23 May 2019.

2. Strong governance program and a culture of accountability. This should include adequate progress and performance metrics, the development of a security-savvy culture and a shift in culture to ensure security practices are a part of people's everyday responsibilities.

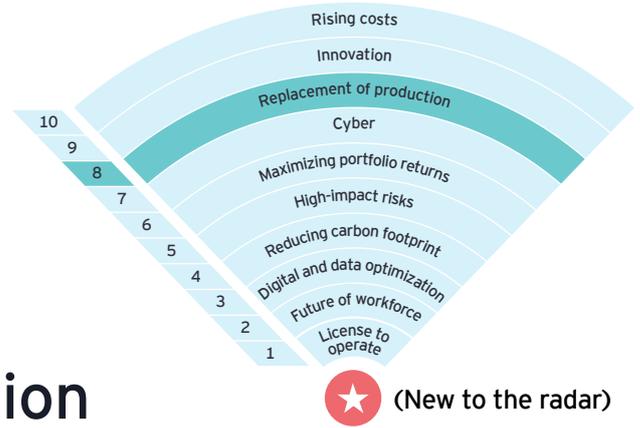
3. Continuous improvement. Adapt to new requirements based on evolving threats and trends and have a plan to regularly assess security posture to remediate gaps. This

plan should include policy, standards and a subset of critical controls that can then be built out over time as awareness and adoption grows. It is important to remember that cyber strategy roles and responsibilities are for everyone in the organization, no matter their role.



08

Replacement of production



Lower exploration budgets, fewer major discoveries and declining grades in existing deposits are particularly concerning when you consider that the outlook is for growing mineral demand as a result of global growth and the demands of new world infrastructure.

Exploration spend has declined significantly, and even though there has been some recovery in the last two years, budgets are still half of what they were in 2012.²¹

Exploration budgets by region by amount budgeted, 2012-18 (US\$m)



Source: S&P Market Intelligence; EY analysis.

There have been few major copper or gold discoveries since 2009. In the case of gold, there have only been 34 deposits discovered over the past decade, containing a mere 213.3 million ounces, only 10% of the gold discovered over the previous 30 years.²² A recent review of gold mines showed that the top gold producers had, on average, 15 years of production left based on current reserves.

In addition, almost two-thirds of copper capacity remain uncommitted. Obtaining investment in the larger projects can prove difficult, but other factors, such as long-running disputes with local communities, environmental hurdles and other regulatory challenges, can also impede the final investment decision.

²¹ "Corporate Exploration Strategies: Overview of exploration trends," *S&P Market Intelligence*, 6 November 2018, accessed on 20 August 2019.

²² "Growth in gold discoveries driven by older deposits," *S&P Market Intelligence*, 28 June 2019, <https://platform.mi.spglobal.com/web/client?auth=inherit#news/article?id=52553370>, accessed on 12 August 2019.



At the same time, the forecasts are for a significant increase in demand for many minerals. The consumption of metals such as iron, copper and nickel in many emerging countries, excluding China, is still low as compared with developed countries. Population and economic growth in many of these markets will be a key driver of future mineral demand.²³ In addition, the energy transition will also push up demand for certain minerals, e.g., demand from renewable energy and storage could exceed reserves for cobalt, lithium and nickel, and demand for copper is projected to increase by 300% by 2050.²⁴

Unless there is a call to arms now for the mining sector to rethink ways of developing known resources, finding new deposits and getting more out of deposits, there could be a significant supply crunch in the next 10-15 years. For those without replacement of production, that will be a lost opportunity.

Strategies for growth in mine supply

► **Access to capital.** More capital is required to increase exploration budgets, but it's likely that new business models are also required. Collaborative capital between majors and explorers, and not just traditional joint ventures, is possibly the way to find the next big resource. Some majors are already exploring alternative relationships with junior miners to expand their resource base. For example, Rio Tinto, through its Kennecott exploration subsidiary, signed a deal to earn up to a 70% interest in Broadway Gold Mining's Madison copper-gold project in Montana in three stages.²⁵ Miners are also seeking investment from their customers, particularly through long-term supply agreements. For

example, Volkswagen has signed a letter of intent with Ganfeng Lithium Co. for the long-term supply of lithium for battery cells for the next 10 years.

- **Acquire existing projects or mines.** M&A has been a focus for major gold miners seeking to boost current reserves, most notably the Barrick Gold and Randgold combination. This is driven by companies having strong balance sheets, a large gap between majors and intermediaries, and no premium versus higher premiums due to competition for assets.
- **Ramp up innovation to both find new resources and extract more value from current resources.** Exploration technologies have already made significant advances as miners explore new digital technologies. These range from the actual finding of new targets, using technologies such as drones to allow greater areas to be covered more exactly, AI to interpret the exploration data and drilling optimization technology to improve sampling. All combined, miners hope the changes will increase falling discovery rates. Ore sorting has seen significant advances in recent years, allowing miners to maximize uptake. Sorting innovation takes place on two key levels – sensor technologies for identification (e.g., X-ray or laser) or digital sorting techniques (for example, advance robots or smart shovels with sensors mounted on the shovel bucket).

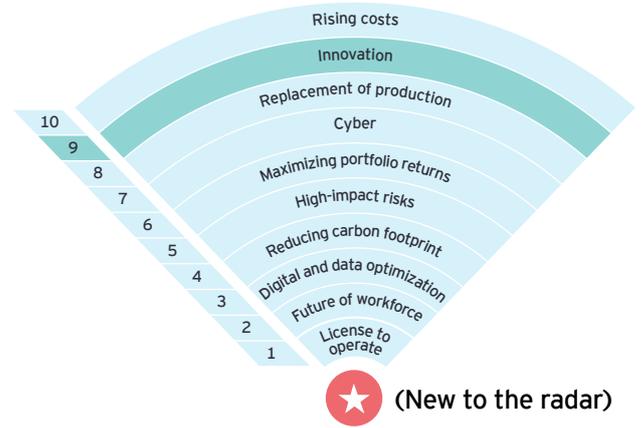
As mining and metals companies adopt new ways of mining and seek out ever more remote locations to find the next big resource, it's going to be essential to pay greater attention to license-to-operate concerns. Greater communication and discussion with key stakeholders will be vital.

²³ "Global distribution of material consumption: Nickel, copper, and iron," *Resources, Conservation and Recycling*, June 2018, <https://www.sciencedirect.com/science/article/pii/S092134491730277X#fig0010>.

²⁴ "Responsible minerals sourcing for renewable energy," *Institute for Sustainable Futures, University of Technology Sydney*, 2019; "Copper demand, supply, and associated energy use to 2050," *Global Environmental Change*, Vol. 39, July 2016.

²⁵ "Broadway options Madison to Rio Tinto affiliate," *Mining Journal*, 30 April 2019, <https://www.mining-journal.com/copper-news/news/1361916/broadway-options-madison-to-rio-tinto-affiliate>, accessed 21 August 2019.

09 Innovation



The burning platform for innovation is clear – some mining companies may need to innovate to survive, while others may be looking at embracing innovation to thrive in today’s fast-changing environment and to improve return on capital. There is certainly clear recognition that significant productivity gains can be made possible by rethinking how work is being done, and by being prepared to innovate.

Innovation could bring a much-needed step change to address key structural issues in the mining sector, namely:

- ▶ Declining ore grades
- ▶ Increased mining in remote and difficult locations
- ▶ Access and cost of energy and infrastructure
- ▶ Increasing operational complexity
- ▶ Improving water management

Innovation needs to disrupt the status quo. We are already seeing successful programs by the majors in this space:

- ▶ Anglo American has trademarked FUTURESMART MINING, which applies innovative thinking and technology to solve mining’s major challenges.

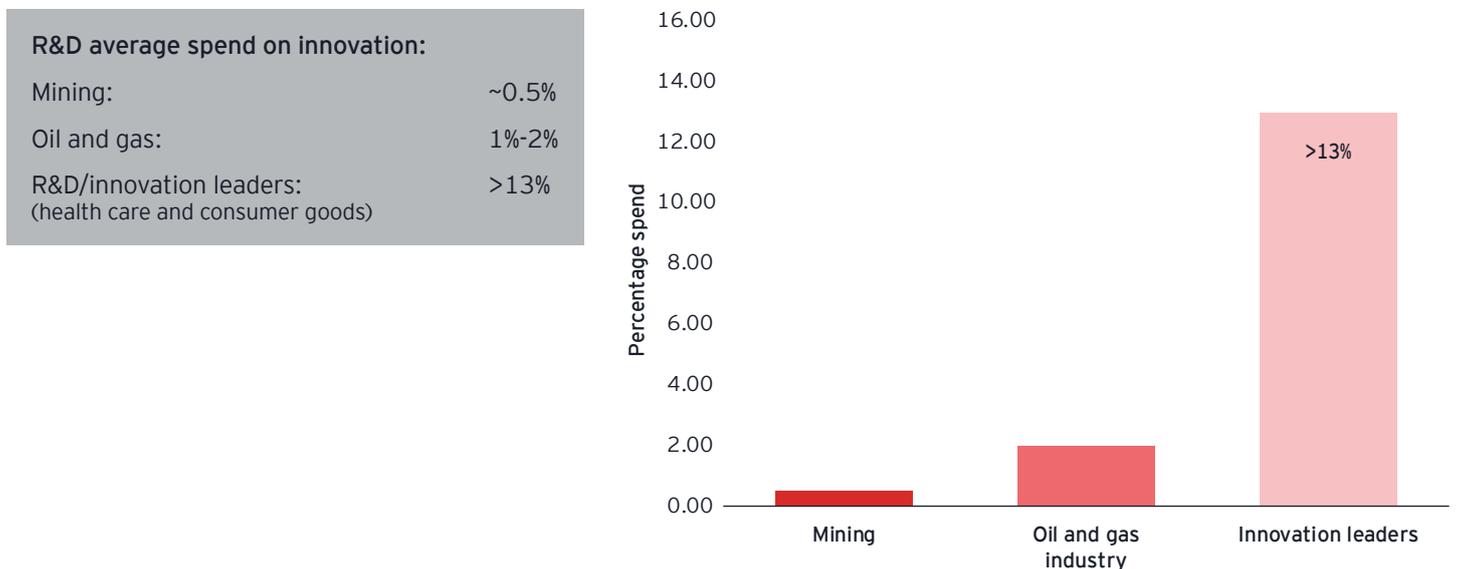
- ▶ Rio Tinto’s Mine of the Future uses smart technology to extract minerals and increase productivity.
- ▶ BHP has a global strategic initiative on value-chain automation.

Successful innovation requires the following:

- ▶ **Executive sponsorship.** Success requires ownership and tone from the CEO downward. A clear vision and road map should be developed and communicated across the organization to provide vision and empowerment.
- ▶ **Funding.** R&D spend in the mining sector is less than half of oil and gas and lags significantly compared with innovation leaders. Yet there is plenty of opportunity for innovation to add value to the mining and metals sector. Investment in innovation could be a game-changer.

Alignment to purpose and strategy. If the innovation program isn’t aligned to purpose and strategy, then it will not add as much value from a market perspective and is far more likely to fail.

R&D average spend on innovation





Have the right structure, systems and processes in place. Innovation tends to be hampered not by a lack of ideas, but by poor execution. Companies need to implement a full operating model for innovation – structure, systems and processes. Recent studies have suggested a dedicated location is critical for the start of an innovation journey, and many universities run dedicated innovation labs.

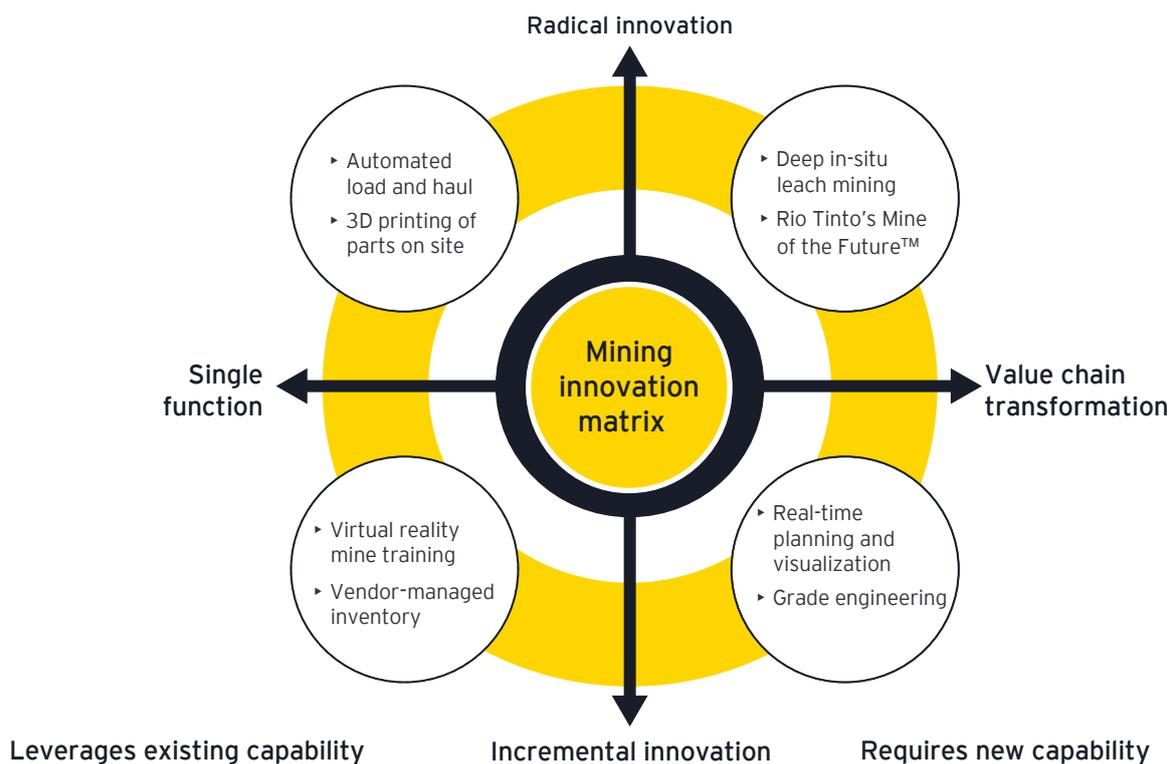
A supportive culture. An innovation culture requires collaboration, common language and common understanding across the organization. Too often, innovation implementation fails due to an ineffective change management program.

An innovation ecosystem. Collaboration will catalyze innovation; it also brings the benefit of cost sharing and de-risking. There have been some successful examples of the mining and metals sector collaborating with other industries and with academia but, on the whole, mining and

metals organizations have often left innovation to the mining equipment, technology and services (METS) sector. R&D is not seen as a core competency of mining, but short-term problem-solving is. However, organizations are reluctant to give small METS companies an opportunity until innovation is proven.

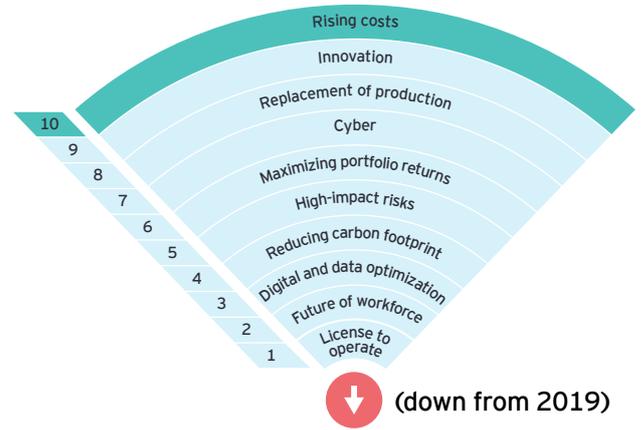
Realistic return on investment expectations. Many see the innovation investment payback as short term, especially with the pressure on shareholder value. Our view is that innovation needs to be a mix of short and long term – it shouldn't be a driver for short-term bottom-line improvements but to improve long-term returns.

Innovation is strategic and value focused, and it is one of the few change programs that is positive in nature and therefore is a huge opportunity that cannot be ignored.



10

Rising costs



As complexity increases, focus remains on rising costs

Rising costs are likely to remain on the risk and opportunities radar as the complexity of mining increases.

Global economic and trade uncertainty is putting pressure on some commodity prices. For example, in the last year, aluminum, zinc and copper have declined by 14%, 8% and 4%, respectively, from 1 August 2018 to 1 August 2019. Slightly tighter margins in these commodities are a reminder of the importance of keeping an eye on costs. Miners need to maintain a focus on building a long-term sustainable cost base, while making certain that cost reduction activities do not contribute to value erosion.

This is particularly important as mining becomes more complex. Head grades are declining, and many low-cost mines are reaching the end of their life. Miners need to go deeper for lower-quality ore and manage increased distances to processing plants, water removal and other physical constraints that come at an increased cost.

Mining operations are also increasingly moving into new regions as desirable mining projects become harder to find. These are often based in remote areas, which can translate into higher costs of energy, water and labor, and a lack of infrastructure. As a result, many miners prefer to expand

existing operations rather than bearing the additional cost burden and risk of greenfield projects.

Cost reduction needs to be sustainable, and a keen focus on productivity will help to manage the impact of rising costs. Automation and increased maturity in the use of data is proving to have significant benefits to large mining operations, in terms of providing an uplift in productivity and hence reduction in production costs per tonne. For example, as Codelco's Chuquicamata mine goes underground and is automated, mine costs will fall from about US\$50/lb to about US\$17/t by 2021.²⁶ Codelco also expects that the deployment of automated trucks at its El Teniente underground copper mine will bring down operating costs by 30%.²⁷

While physical challenges can be addressed by investing capital in new technology and infrastructure, political challenges bring with them increased and constantly changing safety and environmental reporting, causing a substantial increase in compliance costs. Royalty regimes, for example, are increasing in some regions, e.g., Africa. A recent comparison showed that royalties in Chile for a sample of almost 400 global copper mines were less than 9% of total mine costs. But in the Democratic Republic of the Congo which has seen considerable royalty changes over the past year, they are over 15% of total mine costs.

²⁶ S&P Market Intelligence

²⁷ "Codelco puts its mine electrification efforts into first gear," *International Mining*, 26 April 2019, <https://im-mining.com/2019/04/26/codelco-puts-mine-electrification-efforts-first-gear/>.

Labor costs also are on the rise, and negotiations with unions in some countries are becoming increasingly tough as they fight for higher wages. The introduction of more complex technologies and the greater reliability on data also increase spend on salaries, as the skills required are more niche and therefore more expensive.

Steps companies can take to respond to this risk:

- ▶ Focus on sustainable cost reduction programs
- ▶ Encourage innovation and partnerships to help with longer-term reduction of costs

- ▶ Divest noncore assets
- ▶ Review capital tied up in high levels of pre-stripping, advance development and stockpiles
- ▶ Consider the use of contract mining vs. sale or leaseback
- ▶ Review supplier and service contracts
- ▶ Outsource
- ▶ Create strategic joint ventures to optimize economies of scale
- ▶ Reduce costs from a support function – automation in the back office



How EY's Global Mining & Metals Network can help your business

The sector is returning to growth, but mining and metals (M&M) companies face a transformed competitive and operating landscape. The need to improve shareholder returns will drive bold strategies to accelerate productivity, improve margins and better allocate capital to achieve long-term growth. Digital innovation will be a key enabler but the industry must overcome a poor track record of technology implementations. If M&M companies are to survive and thrive in a new energy world, they must embrace digital to optimize productivity from market to mine.

EY takes a whole-of-value-chain approach to support each client to help seize the potential of digital to fast-track productivity, balance portfolios and set a clear road map for their new energy future.

Area contacts

EY Global Mining & Metals Leader

Paul Mitchell
+61 2 9248 5110
paul.mitchell@au.ey.com

Africa

Wickus Botha
+27 11 772 3386
wickus.botha@za.ey.com

Brazil

Afonso Sartorio
+55 21 3263 7423
afonso.sartorio@br.ey.com

Canada

Jeff Swinoga
+1 416 9437 181
Jeff.Swinoga@ca.ey.com

Theo Yameago

+1 6475235279
theo.yameago@ca.ey.com

Chile

Eduardo Valente
+56 2 916 2997
Eduardo.Valente@cl.ey.com

China and Mongolia

Libby Zhong
+86 10 58153541
Libby.Zhong@cn.ey.com

Commonwealth of Independent States

Boris Yatsenko
+7 495 755 98 60
boris.yatsenko@ru.ey.com

France, Luxembourg, Maghreb, MENA, Francophone Sub-Saharan Africa

Christian Mion
+33 1 46 93 65 47
christian.mion@fr.ey.com

Japan

Andrew Cowell
+81 80 2276 4048
andrew.cowell@jp.ey.com

India

Neel Goyal
+91 9811988400
neel.goyal@in.ey.com

Nordics

Lasse Laurio
+35 8 405 616 140
lasse.laurio@fi.ey.com

Oceania

Scott Grimley
+61 8 9429 2409
scott.grimley@au.ey.com

United Kingdom & Ireland

Lee Downham
+44 20 7951 2178
ldownham@uk.ey.com

United States

Bob Stall
+1 404 817 5474
robert.stall@ey.com

Service line contacts

EY Global Advisory Leader

Paul Mitchell
+61 2 9248 5110
paul.mitchell@au.ey.com

EY Global IFRS Leader

Tracey Waring
+61 3 9288 8638
tracey.waring@au.ey.com

EY Global Tax Leader

Andrew van Dinter
+61 3 8650 7589
andrew.van.dinter@au.ey.com

EY Global Climate Change and Sustainability Services Leader

Matthew Nelson
+61 403 045 446
mathew.nelson@au.ey.com

EY | Assurance | Tax | Transactions | Advisory

About EY

EY is a global leader in assurance, tax, transaction and advisory services. The insights and quality services we deliver help build trust and confidence in the capital markets and in economies the world over. We develop outstanding leaders who team to deliver on our promises to all of our stakeholders. In so doing, we play a critical role in building a better working world for our people, for our clients and for our communities.

EY refers to the global organization, and may refer to one or more, of the member firms of Ernst & Young Global Limited, each of which is a separate legal entity. Ernst & Young Global Limited, a UK company limited by guarantee, does not provide services to clients. Information about how EY collects and uses personal data and a description of the rights individuals have under data protection legislation are available via ey.com/privacy. For more information about our organization, please visit ey.com.

© 2019 EYGM Limited.
All Rights Reserved.

EYG no. 004427-19Gbl

BMC Agency
GA 1012053

ED None



In line with EY's commitment to minimize its impact on the environment, this document has been printed on paper with a high recycled content.

This material has been prepared for general informational purposes only and is not intended to be relied upon as accounting, tax or other professional advice. Please refer to your advisors for specific advice.

The views of third parties set out in this Publication are not necessarily the views of the global EY organization or its member firms. Moreover, they should be seen in the context of the time they were made.

ey.com/miningmetals